STEELCRETE HANDBOOK

Steelcrete

A HAND-BOOK OF DESIGN

Containing Tables, Standards, and Useful Information

"Steelcrete" Mesh

Steelcrete

TRADE MARK

The Consolidated Expanded Metal Companies

General Offices and Works

Braddock, Pa.

(In the Pittsburgh District)

Sales Offices and Warehouses

Chicago — Philadelphia — Pittsburgh

Distributors

New York	Expanded Metal Engineering Co.
Boston	Penn Metal Company
Toronto	Baines & Peckover
Dallas	Builders Metal Products Co.
San Francisco	Holloway Expanded Metal Co.

This is Copy

No. E_______

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60,000 square feet of "Steelcrete" Mesh (25 tons) is here shown in a pile on the floor. The compact form in which this material is shipped could not be better illustrated. The upright bundle of mesh illustrates the perfect nesting of the sheets obtained because of the uniform quality of steel used

FOREWORD

THE need of a Handbook of design embodying a large number of handy reference tables, and boiling down into easily digested form, formulae of reinforced concrete, has been felt in every field of engineering endeavor. With the end in view, therefore, to serve a wider field than ever before, this edition of the Steelcrete Handbook revised and enlarged is offered.

The War which has just been brought to a successful conclusion called upon the industries of the country to give their maximum services. It was early recognized that it would be a war between the industries of two groups of nations, as well as between their military organizations.

Since the beginning of the World War in 1914, Expanded Metal did its bit in contributing to the winning of the war. The English and French Expanded Metal Companies dedicated their entire output to war purposes. The limit of the material furnished was fixed only by the limit of their output.

Since the entry of our own country into the war, the demand for Expanded Metal on the part of our own Government exceeded any demand heretofore known. This Company, taxed to its capacity for output, has reason to be proud of the part it played between the interval of February 1918 to November 1918, the period of greatest activity of the American armies.

Upwards of 7,000,000 sq. ft. of Expanded Metal was shipped by this company overseas at a time when shipping space was valued by the lives of our soldiers. Expanded Metal, because of its marked adaptability to the work required of it as well as because of its wide and successful application by our allies throughout the Western Front, was sent over in shiploads. The use to which most of the material was put is only slightly known. Dugouts, revetments and gun emplacements called for concrete work to be subjected to undulating strains impossible to calculate. This opened a wide field of service for a reinforcement of flat sheets, having the many distinguishing features of Expanded Metal. Not only for overseas was this material demanded but much greater quantities were used on this side of the water.

A sheet of "Steelcrete" Mesh 6 feet wide and 16 feet long is here shown. Flat sheet reinforcement assures rigidity and the correct position after pouring of concrete

"STEELCRETE"

"Steelcrete" A Widely Used Reinforcement

NEARLY thirty years ago, "Steelcrete" expanded metal took its place in the front rank of concrete reinforcement and today, it continues its enviable position as the oldest and most widely-used system.

To those who have not been associated with the reinforced concrete industry, for any length of time, there should be addressed a word as to the extremely widely-known uses to which expanded metal has been put in foreign countries. Expanded metal has been used not only in every portion of the United States but in every corner of the civilized world — in fact, wherever modern civilization has thrust itself, expanded metal construction will be found in the most important works of that country. Of American invention, no product could be more widely endorsed by the world's engineers.

The square feet of expanded metal used today in the United States is triple what it was at any time in its past history prior to the last five years.

Properties of Steel Employed Unattainable Elsewhere

Undoubtedly, the only reason expanded metal has stayed in the first rank of concrete reinforcement for the last thirty years — ever since the early days of the industry — under the critical scrutiny of the best-known engineers of the entire civilized world, is that its underlying principles have been recognized to be fundamentally correct. The problems of reinforced concrete today are the same as they have been since the inception of the industry. There is no need to enter into a theoretical discussion to obtain the admission of the principle that steel and concrete must act together in insuring the strength and rigidity of a structure. To attain this end, the most perfect bond between the concrete and the steel must be attained. Moreover, more attention has been given in recent years to the properties of the steel employed than ever before. The elasticity of the steel is for all practical purposes about equal to that of the concrete before the "elastic limit" in steel is attained. When this "elastic limit" is passed reinforced concrete failure occurs. This fact

has been known for many years but the difficulty encountered by the engineering profession has always been that it was impractical to obtain a suitable quality of steel possessing a high elastic limit — synonymous with an ideal steel for reinforced concrete — and at the same time to preserve the most essential property of steel, i. e., that it should be of uniform quality. Attempts have always been made to attain this high elastic limit by the use of high carbon steel. Steel manufacturers looked askance when the reinforced concrete engineering profession undertook to utilize this decidedly erratic grade of steel. It is not possible, even under present methods of steel manufacture, to commercially turn out a high carbon steel bar with the degree of certainty that can be obtained in medium steels. An unanswerable proof in substantiation of this statement is found in the fact that the structural steel industry, with its enormous tonnage, uses by preference, medium steel, and the steel used for railroad bridges, where the greatest stresses and jars are anticipated, is an even softer grade of steel. In this connection, it should be stated that soft steel can be attained only by low carbon content.

Purpose of "Steelcrete" Handbook

The rapid growth of concrete construction is bringing each day into the industry new forces in the character of engineers, superintendents, and contractors, not to mention new capital. Modern competition requires that all of these forces fully inform themselves on past practice as well as on the most up-to-date and widely-used methods in their particular field. Were it not for this reason, there would be no need of issuing and re-issuing any "Steelcrete" handbook. "Steelcrete" mesh is a part of so much important work throughout the United States that it is known even to the man who has only an occasional reason for delving into reinforced concrete work. No material, however meritorious, would be of long service to the trade were it not accompanied by full, technical information and explanations not only to aid the daily user of the material but to present in a concrete form the information necessary for a new man to arrive at his choice of reinforcement. No reinforced concrete work is undertaken without careful thought

on the part of the engineer, always designing with the end in view of improving on the last work he undertook. Improvement upon improvement has been one of the main reasons for the rapid strides of reinforced concrete. The material is meritorious — unquestionably so — nevertheless, improper application and careless designs may nullify all the beneficial effects to be attained by the proper use of this remarkable building material. This has been recognized by every individual or concern interested in the development of reinforced concrete. The large Cement Associations engaged in promotion work have made enormous expenditures with the end in view of educating the industry to the possibilities in the use of this material.

A Correct Reinforcement

Weaknesses appearing in a finished reinforced concrete structure are irremediable. Years after completion, steel structures are reinforced with plates and shapes because of a character of loading not considered or rigidity unattained by the original design. It should be borne in mind that this is not feasible in the case of a reinforced concrete structure, which is exceedingly difficult to alter after it is once poured. Thus, the fact is emphasized that this most flexible of modern building materials must be correctly used and more especially, the reinforcement must be carefully selected.

Indeterminable Stresses are Real Ones

Recent developments have laid great emphasis upon the fact that reinforced concrete, to attain its greatest degree of usefulness, must be as nearly free from cracks as possible. To accomplish this, buildings and structures of all kinds must be designed for rigidity. They must be capable of absorbing those shocks and strains, which although admitted, are unrecognized by building codes and specifications, but which engineers universally know to exist, and greatly apprehend. We refer to such stresses as are obtained in the sudden jar encountered in the passing of a moving load, a heavy concentrated load where it was not expected by the designer, or the dropping of a heavy weight, any one of which will produce stresses which far surpass the ordinary calculated uniform values. It should be kept in mind by everyone that the strains

which are ordinarily provided for by the Engineer and which are covered by tables and formulas widely used offer protection only against quiescently applied and uniformly distributed loads. No formula or table provides against the strains produced by a sudden shock or a high wind stress or the vibration of a building caused by machinery in operation, yet all of these stresses are real stresses. They are responsible for weaknesses in many buildings and structures. Provision for these indeterminate stresses can only be made by the use of a reinforcing system which is capable of withstanding without injury to the concrete many times the quiescently applied load for which it was designed, one which takes care of and absorbs a concentrated or suddenly applied load.

Since the introduction of reinforced concrete, the distribution of the steel in the concrete has been the great object of investigation. Systems innumerable have been advanced and examples of successful construction in numerous bridges, buildings, etc., are used by the various promoters to argue the relative advantages. The inevitable result of discussion and experiment must be and has been the survival of the fittest, until now the peculiar advantages and disadvantages of any system are readily discernible. All systems aim more or less — some crudely — to fulfill the recognized requirements of the steel and to develop in full the possibility of the concrete. We contend that in the light of experience, "Steelcrete" expanded metal has been unmatched by any other system in providing for the uncertain stresses encountered in reinforced concrete work and at the same time providing for an economical and practical reinforcement for a contractor taking into account the unskilled labor he is required to use.

A High Elastic Limit and Ductility

In order to emphasize the importance of the principles touched upon in the foregoing, it is mandatory to amplify some of the outstanding features:

First — Any meritorious system of reinforcement must use a quality of steel which shall possess a high elastic limit provided only that such elastic limit is obtained in a uniform

product and without accompanying loss of ductility. Steel with little ductility signifies that when it fails it ruptures suddenly with little or no previous indication of failure. Ductile steel will elongate or twist before breaking, thereby adding a measurable degree of strength. It acts as a shock absorber in overstrained structures. It minimizes the possibility of collapse.

"Steelcrete" expanded metal provides a low carbon steel with a high elastic limit. The carbon contents are .08 to .10 per cent. The full value of this will not be recognized by the ordinary lay-reader but will be immediately grasped by any structural engineer, more especially, by a steel manufacturer. It is synonymous with saying that the steel is as nearly a uniform quality as a commercial product can be turned out. "Steelcrete" expanded metal provides an elastic limit unattained in any low carbon steel by virtue of the process of manufacture. It is sufficient to say at this point that expanded metal has been repeatedly tested and to refer the inquirer to the chapter on tests conducted under the auspices of the Columbia University Testing Laboratory embodied in this handbook. The ductility of expanded metal is such that any strand cut from any normal sheet on the field may be bent flat on itself — a property almost incredible in a steel possessing an "elastic limit" of 55,000 to 65,000 pounds per square inch.

A Web-Like Structure

Second — Provision must be made for the absorption of falling loads or jarring of a building caused by revolving machinery, as well as by wind stresses. The web-like structure of expanded metal distributes the stresses to other portions of the slab and thus constitutes the ideal method of obtaining a reinforcement providing for these uncertain yet commonly occurring loads in actual practice. Proper provision against such jarring means the minimizing of cracks and the assured permanence of the concrete structure.

Does Away with Intricate Blueprints on a Job

Third — One of the constant worries attendant not only on the engineer designing the reinforced concrete structure but on the contractor engaged in the execution of the work is the correct position and location of the steel in the concrete.

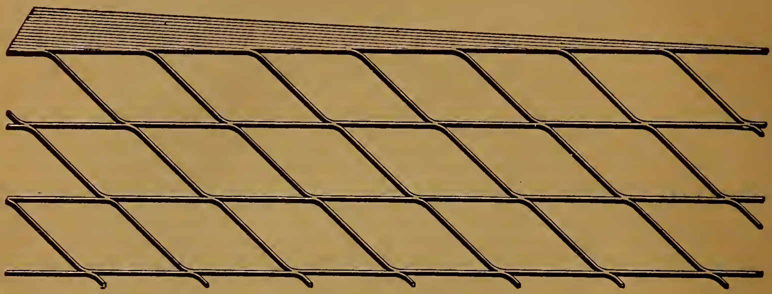


Fig. (1)—Showing process of manufacture of a deployed mesh. This was at one time a widely used reinforcement

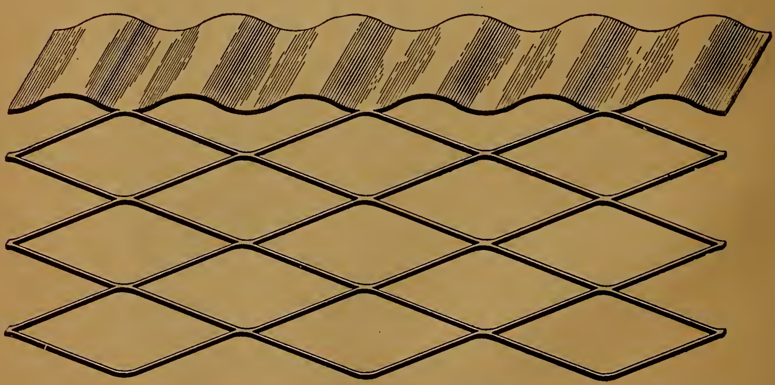


Fig. (2)—Another illustration of a later deployed mesh

Fig. (3)—"Steelcrete" Mesh, showing present process of manufacture of the cold-drawn mesh. This process has supplanted completely the two preceding ones shown

What Is "Steelcrete" Mesh?

THE preceding illustrations depict the difference between the old and the new product. "Steelcrete" mesh is manufactured by a cold-drawn process. It, therefore, possesses great unit strength and a high elastic limit. A mesh that is not cold drawn but merely deployed is necessarily low in value in both of these properties. A distinctive feature of "Steelcrete," in addition to above, is its uniformity of quality and stiffness. It makes a taut reinforcement, requiring no stretching to take the "waves" out of it. You can be sure of what you are getting by specifying "Steelcrete" mesh.

"Steelcrete" mesh is not a new system, nor does it require formulas peculiar to itself. It does, however, provide a system which fulfills the most difficult and exacting requirements in respect to the disposition of the embedded steel. In this regard "Steelcrete" expanded metal stands out pre-eminently and alone by reason of its two great features — the elimination of doubt and 100 per cent efficiency of steel. In these two attributes, this system out-distances all competitors. It may be safely predicted that if reinforced concrete work will follow other lines of engineering endeavor and will continue to hold its place as a sound and sane construction, all principles, systems or members whose usefulness cannot be definitely assured and whose value in practical work cannot be ascertained or which are in any way uncertain in practical application will be ultimately supplanted in all important construction by such systems as best fulfill these requirements — requirements which are exacted in every other branch of engineering endeavor.

What "Steelcrete" Mesh Is

"Steelcrete" Expanded Metal, at once the oldest and most widely-known concrete reinforcement, has itself undergone developments until it possesses today all the qualities above described. It is not uncommon, however, to find engineers and contractors, long in the business, who are unacquainted with the properties of this material.

A Cold drawn Fabric

"Steelcrete" Expanded Metal is not a steel plate which has been slit in one operation and in the second operation pulled and enlarged into a large sheet of diamond-shaped meshes. In the "Steelcrete" process, the diamond-shaped meshes are formed by cold drawing the metal at an enormous speed by intensely developed and highly specialized machines. The preceding illustrations indicate just what is meant by the term "Steelcrete Expanded Metal." Being a mesh which is manufactured by a cold drawn process it possesses great ultimate strength and high elastic limit. The distinctive feature of "Steelcrete," in addition to the above, is its uniformity

of quality and stiffness. It makes a taut reinforcement requiring no stretching to take the "waves" out of it.

It is this cold working of the steel at exceedingly high speeds that gives to "Steelcrete" expanded metal its distinguishing properties. The metal has not been deployed, but has been cold drawn to its diamond mesh shape. Additional distinguishing features of "Steelcrete" expanded metal are the accuracy of the manufacture of its strands, the improved mechanical appearance of the material, and most important of all, the stiffness of the flat sheet. The illustrations on pages 4 and 6 were included for the purpose of conveying some idea of the incredible rigidity of this product of flat sheet form. This is only made possible by its mechanical construction. The advantages of this stiffness in connection with the distribution of the steel in the concrete is too obvious to dwell upon.

The effect of the process on the steel in making "Steelcrete" expanded metal is not unlike the cold-twisting of a square bar, the cold rolling of a steel shape, or in fact, the cold working of any piece of steel by which due to strange phenomena characteristic of this metal, the quality is improved, the ultimate strength increased and its elastic limit more than doubled. The original plate is of soft open hearth steel containing a low percentage of carbon. In the finished product, the ultimate strength has been raised from 20 to 50 per cent and its elastic limit increased by 100 per cent. From the very beginning of reinforced work, the success of "Steelcrete" expanded metal has been continuous. Innumerable tests have been made and always the results have proven better than expected.

Uniformity of Material

"Steelcrete" expanded metal is strictly speaking a material with a high elastic limit. This ranges from 55,000 to 65,000 pounds per square inch. The value of these figures for a concrete reinforcement will be recognized by all students of this class of material. In addition to this great advantage is the guarantee of uniformity of material due to the soft steel plate from which the fabric is made. A high elastic limit is usually synonymous with uncertainty. In "Steelcrete" expanded

metal, we have a material possessing a high elastic limit and at the same time a guaranteed uniformity of quality and a low ductility.

On pages 6 and 13 are found reproduction of sheets of "Steelcrete" expanded metal. Its structure should be carefully noted. It will be seen that the openings are amply large enough to permit the concrete to completely surround and embed the steel. We have elsewhere dwelt upon the importance of the bond and the guarantee of strength in this respect offered by the use of "Steelcrete" mesh. It is obvious that because of its structure, no possibility of slipping is encountered. It is unique in metal fabrics for reinforcing slabs. Its diamond-shaped structure provides a distinctive feature to which we desire now to draw your attention and the value of which has only been touched upon heretofore. The strands are seen to extend in every direction. A sudden concentrated load which would prove fatal to any straight-line reinforcement is amply taken care of here as the stress will be distributed to all the adjoining strands.

The Structure of "Steelcrete"

The illustrations on page 19 bring out exactly the point to be noted at this time. All of the adjoining strands in proximity to the concentrated load are immediately put into tension. In straight-line reinforcement only three or four wires or rods are commonly available for this purpose. Its weakness in this respect is obvious. "Steelcrete" expanded metal provides a hammock-like resistance to the concentrated load. No better protection against the unforeseeable could be found than is offered here. Engineers are forced to design what are quiescently applied and uniformly distributed loads in the absence of any better method, although such loads are the least likely to occur in practice. On the other hand, the heavy concentrated load or the dropping of a heavy weight from as short a height as one foot will produce stresses which far surpass the ordinary calculated uniform ones.

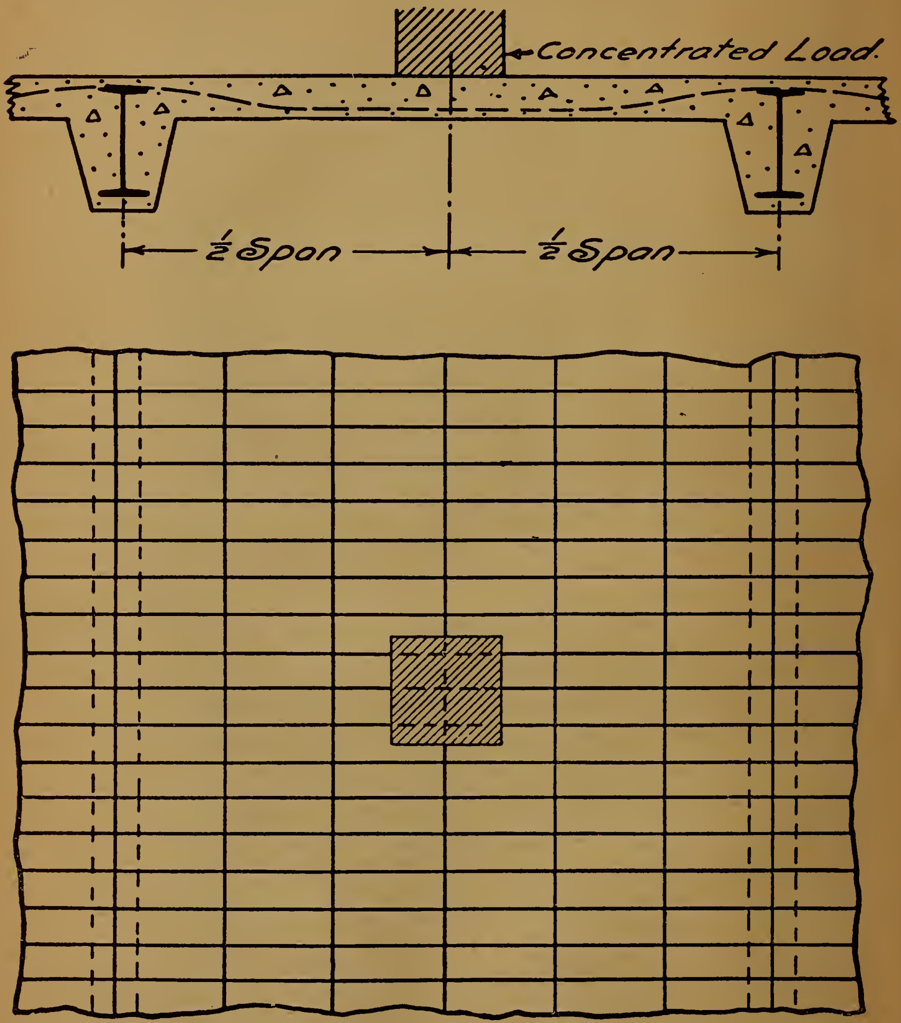
In buying a reinforcement, buy that which gives the greatest protection against what cannot be foreseen, but which

is nevertheless certain. "Steelcrete" meshes furnish a protection against shocks, internal or external explosions and sudden drops of heavy loads within the building. When "Steelcrete" expanded metal is chosen a material is selected which has stood the test of almost thirty years in actual work and which is unsurpassed in quality, structure or efficiency at the present day.

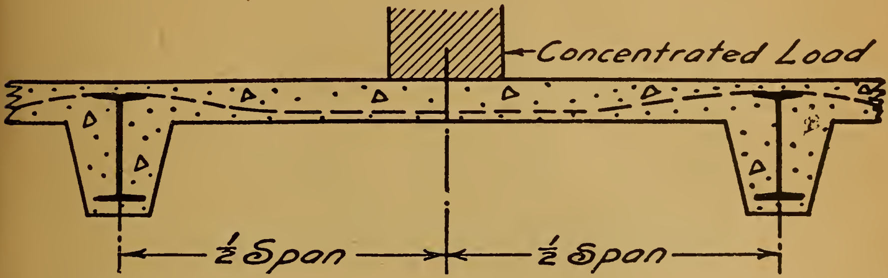
Reinforced concrete has been sometimes called structural concrete. The fact is thereby implied that it is subject to mathematical investigation. Its stresses and their characters may not be as definitely known as those of structural steel, but the function of each member has been empirically ascertained, more especially that of the steel and its location in the concrete. "Steelcrete" mesh offers a complete solution of the uncertainty encountered in the placing of the steel in the concrete. *It is pre-eminently a reinforcement for unskilled labor.* Engineers may figure long over and delve deeply into their mathematics, but it must be admitted that *it is the common laborer who determines the final position of the neutral axis.* It is brawn rather than brains that finally determines the safety of the structure. All modern engineering is concentrated in an effort to eliminate the human element and take away from unskilled labor the ability to reduce the value of a structure by lack of knowledge of the essentials. "Steelcrete" Mesh shipped in flat sheets offers a complete solution to this problem. The foreman on the job does not even require ability to read a blue print. A large area may be covered without spacing. The stiffness of a "Steelcrete" expanded metal sheet has already been referred to. The ease in handling offered by comparatively small, stiff, flat sheets makes it the popular reinforcement for the contractor.

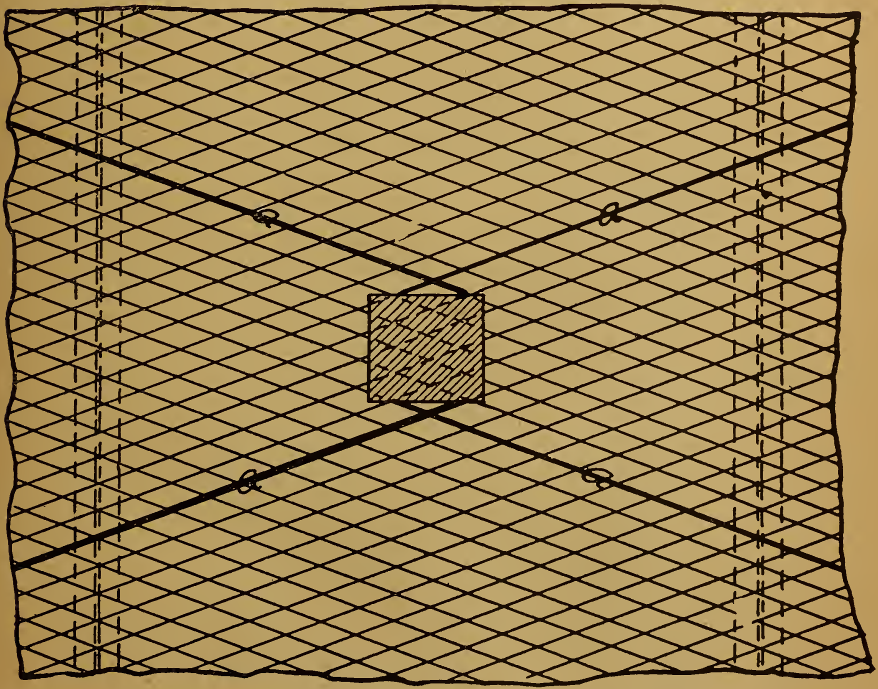
The Long Roll vs. the Flat Sheet

"Steelcrete" Mesh lies naturally in the plane of tension designed for it. This is not so in the case of a long roll reinforcement. The long roll does not offer the guarantee of placing the reinforcement exactly as required. While cross-wires may space it correctly in the horizontal plane, the unrolled fabric, however, has a wavy or warped form in practice, offering an



How straight line reinforcement takes care of a concentrated load. Only three or four wires or rods commonly available for this purpose. The weakness in this respect is obvious





How "Steelcrete" Mesh takes care of a concentrated load. All the strands within the heavy lines a-a are aiding directly to sustain it. The strands without, also are in tension, to a lesser extent

element of uncertainty as regards its position in the vertical plane. If in a common slab, with an effective depth of only three or four inches, the reinforcement, because of its form, becomes displaced a half inch in vertical direction, the strength of the slab becomes greatly impaired. *The fact that tests do well proves little. The placing is then under expert supervision.* In practice the placing is left to unskilled labor. The position of the reinforcement in the vertical plane is obviously of far greater importance than in the horizontal plane.

A reinforcement that does not rest absolutely flat but curves vertically even to a slight extent, cannot prove effective until it has stretched tight. This necessitates a slipping in the concrete and a breaking of the bond in the readjustment of the steel. The detriment to the slab is obvious. This is all avoided by the use of "Steelcrete" mesh. The correct position of the steel is assured, both vertically and horizontally. No slipping in the concrete is necessary for initial tension. Unskilled labor with ordinary supervision gives satisfaction in placing. The architect or engineer is relieved of anxiety over an uncertain problem, while the contractor is freed from the responsibility of a matter he feels should be beyond his sphere.

The Importance of Bond

None the least of the lessons to be learned from the tests on reinforced concrete structures is the tremendous importance of securing a reinforcement in which the bond obtained between the steel and the concrete is the maximum. When "Steelcrete" Expanded Metal is chosen, the question of bond is one about which the Engineer need have no concern whatsoever. The bond attained between the diamond meshes, all under tension, is the most perfect that ingenuity could devise. No possibility of slipping is encountered. The connecting ties are stronger than the strands themselves. Their strength does not depend on the care of a common laborer in their manufacture, as it is mechanically impossible to vary this tie in a measurable amount. The possibility of slipping is eliminated from reinforced concrete work. When the steel has slipped it can take no stresses from the concrete.

Steel and concrete, by a fortunate combination of desirable properties, unite to form a building material surpassed by none. In order for them to work together it is evident that the bond should be as nearly perfect as possible, as the stresses must be continually transmitted from the steel into the concrete and from the concrete into the steel. It is evident from the inspection of a sheet of "Steelcrete" mesh that the bond attained by the enmeshing of the concrete is perfect. There is seen to be no possibility of slippage. In addition to this, the individual strands have the rough surface of a sheared bar, which makes an ideal grip for the cement.

General Theory and Design

In selecting a basis for design of concrete steel structures, the engineer, architect or contractor has in view two ultimate objects — first, the safety of the building — second, the economy of construction. Hence, the general requirements that they should first err on the side of safety — secondly, all other things being equal, the simplest is the most desirable. Reinforced concrete is a complex material and hair-splitting accuracy in design is neither possible nor necessary. While such structures can be subjected to rigorous mathematical investigation, the formulas deduced are complex and unwieldy and the results obtained, compared with those of more simple formulas in common use, do not warrant the refinement.

As long ago as 1903 and 1904, in the interests of simplicity and uniformity, special committees were appointed by the American Society of Civil Engineers, American Society for Testing Materials, American Railway Engineering and Maintenance of Way Association and the Association of American Portland Cement Manufacturers to confer and unite in recommending necessary factors and formulas required in designing of structures in which concrete steel is used. This committee was called the "Joint Committee" and from time to time has made reports to their various societies embodying a summary of practical formulas and general uniform assumptions as a

basis for calculations relating to strength of structure. These formulas and assumptions are so widely used that they form the basis of reinforced concrete design in the United States. The aim in view has been to arrive at simplicity, believing that refinement is unnecessary in ordinary routine work. No better basis for calculations of tables could be found than were embodied in this report. The final report was made in July, 1916, and is given in full herewith with the end in view that it may be embodied in this handbook in handy reference form for all investigators of the mathematics of reinforced concrete structures.

Final Report

of the

Joint Committee on Concrete and Reinforced Concrete

Preliminary Draft Prepared and Submitted by the Secretary, October 27, 1908
Amended and Adopted by Letter Ballot of the Committee, December 20, 1908
Revised and Brought up to Date, November 20, 1912
Final Report Adopted by the Committee, July 1, 1916

AFFILIATED COMMITTEES

OF THE

American Society of Civil Engineers
American Society for Testing Materials
American Railway Engineering Association
Portland Cement Association
American Concrete Institute

July 1, 1916

Chapter I

Introduction

THE Joint Committee on Concrete and Reinforced Concrete was formed by the union of Special Committees appointed in 1903 and 1904 by the American Society of Civil Engineers, the American Society for Testing Materials, the American Railway Engineering and Maintenance of Way Association (now the American Railway Engineering Association), and the Association of American Portland Cement Manufacturers (now the Portland Cement Association). In 1915 there was added a Special Committee appointed by the American Concrete Institute at the invitation of the Joint Committee.

The present organization and membership of the Joint Committee is as follows:

Officers

Chairman — Joseph R. Worcester.
Vice-Chairman — Emil Swensson.
Secretary — Richard L. Humphrey.

Members

American Society of Civil Engineers

John E. Greiner, Consulting Engineer, Baltimore, Md.

William K. Hatt, Professor of Civil Engineering, Purdue University, Lafayette, Ind.

Olaf Hoff, Consulting Engineer, 149 Broadway, New York, N.Y.

Richard L. Humphrey, Consulting Engineer, 805 Harrison Building, Philadelphia, Pa.

Robert W. Lesley, Past-President, Association of American Portland Cement Manufacturers, Pennsylvania Building, Philadelphia, Pa.

Emil Swensson, Consulting Engineer, 925 Frick Building, Pittsburgh, Pa.

Arthur N. Talbot, Professor of Municipal and Sanitary Engineering, University of Illinois, Urbana, Ill.

Joseph R. Worcester, Consulting Engineer, 79 Milk Street, Boston, Mass.

American Society for Testing Materials

William B. Fuller, Consulting Engineer, 150 Nassau Street, New York N. Y.

Edward E. Hughes, General Manager, Franklin Steel Works, Franklin, Pa.

Richard L. Humphrey, Consulting Engineer, 805 Harrison Building, Philadelphia, Pa.

Albert L. Johnson, Vice-President and General Manager, Corrugated Bar Company, Mutual Life Building, Buffalo, N. Y.

Robert W. Lesley, Past-President, Association of American Portland Cement Manufacturers, Pennsylvania Building, Philadelphia, Pa.

Gaetano Lanza, The Montevista, Sixty-third and Oxford Streets, Overbrook, Philadelphia, Pa.

Leon S. Moisseiff, Consulting Engineer, 69 Wall Street, New York, N. Y.

Henry H. Quimby, Chief Engineer, Department of City Transit, Bourse Building, Philadelphia, Pa.

Sanford E. Thompson, Consulting Engineer, 136 Federal Street, Boston, Mass.

Frederick R. Turneaure, Dean of College of Mechanics and Engineering, University of Wisconsin, Madison, Wis.

Samuel Tobias Wagner, Chief Engineer, Philadelphia and Reading Railway Company, Reading Terminal, Philadelphia, Pa.

George S. Webster, Director, Wharves, Docks and Ferries, Bourse Building, Philadelphia, Pa.

American Railway Engineering Association

H. A. Cassil, Division Engineer, Baltimore and Ohio Railway Company, New Castle, Pa.

Frederick E. Schall, Bridge Engineer, Lehigh Valley Railway Company, South Bethlehem, Pa.

Frederick P. Sisson, Assistant Engineer, Grand Trunk Railway, Detroit, Mich.

Joseph J. Yates, Bridge Engineer, Central Railroad of New Jersey, 143 Liberty Street, New York, N. Y.

Portland Cement Association

Norman D. Fraser, President Chicago Portland Cement Company, 30 North La Salle Street, Chicago, Ill.

Robert E. Griffith, Vice-President, Giant Portland Cement Company, Pennsylvania Building, Philadelphia, Pa.

Spencer B. Newberry, President, Sandusky Portland Cement Company, Engineers' Building, Cleveland, Ohio.

American Concrete Institute

Edward Godfrey, Structural Engineer, Robert W. Hunt & Co., Monongahela Building, Pittsburgh, Pa.

Egbert J. Moore, Chief Engineer, Turner Construction Company, 11 Broadway, New York, N. Y.

Leonard C. Wason, President, Aberthaw Construction Company, 27 School Street, Boston, Mass.

Progress reports by the Joint Committee were presented to the parent societies in 1909 and 1912. The report presented in 1912 has been printed by the American Society for Testing Materials and the American Railway Engineering Association, and reference to that report may be made for details regarding the earlier work of the Joint Committee, a historical sketch of the introduction of concrete and reinforced concrete, and a bibliography of authorities upon which the report was based.

The Committee has been much gratified at the reception accorded its 1912 report, and realizes the responsibility which rests upon it because of the very extensive adoption of its recommendations in current practice in this country. The members of the Committee are well aware of the incompleteness of that report, and even now they are unable to pass judgment upon some matters not dealt with in the present report.

Since 1912 the Committee has continued its study of the subject, has followed the working out of its recommendations in actual construction, has weighed arguments and criticisms which have come to its attention, and has considered new experimental data. While the Committee sees no reason for making any fundamental changes, the recommendations of its previous report have been revised to some extent, and considerable new material has been added upon subjects not pre-

viously touched. There are some subjects upon which experimentation is still in progress, and the art of concrete and reinforced concrete will be advancing for many years to come.

While this report deals with every kind of stress to which concrete is subjected and includes all ordinary conditions of proportioning and handling, it does not go into all types of construction nor all the applications to which concrete and reinforced concrete may be put. The report is not a specification but may be used as a basis for specifications. In their use concrete and reinforced concrete involve the exercise of good judgment to a greater degree than do any other building materials. Rules cannot produce or supersede judgment; on the contrary, judgment should control the interpretation and application of rules.

The Committee has not attempted in every case to present rigidly scientific methods of analysis in dealing with stresses, but has aimed to furnish rules which will lead to safe results sufficiently close for ordinary design.

The Committee presumes that the application of the recommendations in this report to the design of any structure will be made only by persons having an adequate knowledge of the principles of structural design. Only persons with such knowledge and experience should be called upon to design reinforced concrete structures.

The Joint Committee has reached the conclusion that, with this effort to express the present state of the art, it would be desirable for it to withdraw from the field. This action has been taken in the hope that a work similar to that which the Committee has attempted to perform will again be undertaken, within a reasonable term of years, in order that there may be some authoritative body to consider and pass upon newly acquired knowledge and information, gleaned from experience. The Committee feels certain, however, that it would be for the better interest of the profession to entrust this work to other hands rather than to continue the present organization with this object in view.

Chapter II

Adaptability of Concrete and Reinforced Concrete

THE adaptability of concrete and reinforced concrete for engineering structures or parts thereof, is so well established that they are recognized materials of construction. When properly used, they have proved satisfactory for those purposes for which their qualities make them particularly suitable.

Uses

Plain concrete is well adapted for structures in which the principal stresses are compressive, such as:—foundations, dams, retaining and other walls, tunnels, piers, abutments, and, in many cases, arches.

By the use of metal reinforcement to resist the principal tensile stresses, concrete becomes available for general use in various structures and structural forms. This combination of concrete and metal is particularly advantageous in structural members subject to both compression and tension, and in columns where, although the main stresses are compressive, there is also cross-bending.

Metal reinforcement may also be used to advantage to distribute and minimize cracks due to shrinkage and temperature changes.

Precautions

Failures of reinforced concrete structures have been due usually to some one or more of the following causes:

Defective design, poor material, faulty execution, or premature removal of forms.

To prevent failures or otherwise unsatisfactory results, the following precautions should be taken:

The computations and assumptions on which the design is based should be in accordance with the established principles of mechanics. The unit stresses and details of the design should conform to accepted good practice. Materials used for the concrete as well as for the reinforcement should be carefully inspected and tested, special attention being given to the

testing of the sand, as poor sand has proved a frequent cause of failure. The measuring and combining of the materials which go to make up the concrete, and the placing of the concrete in the forms, should be under the supervision of experienced men. The metal for reinforcement should be of a quality conforming to standard specifications. Care should be taken to obtain good bond between different fills of concrete, to prevent concrete from freezing before the cement has set, to have the materials thoroughly mixed, to avoid too wet or too dry a consistency, and to have the forms cleaned before concrete is placed.

The computations should include all details; even minor details may be of the utmost importance. The design should show clearly the size and position of the reinforcement, and should provide for proper connection between the component parts so that they cannot be displaced. As the connections between reinforced concrete members are frequently a source of weakness, the design should include a detailed study of such connections.

The concrete should be rigidly supported until it has developed sufficient strength to carry imposed loads. The most careful and experienced inspection is necessary to determine when the concrete has set sufficiently for it to be safe to remove forms. Frozen concrete frequently has been mistaken for properly set concrete.

Design and Supervision

The execution of the work should not be separated from the design, as intelligent supervision and successful execution can be expected only when both functions are combined. It is desirable, therefore, that the engineer who prepares the design and specifications should have supervision of the execution of the work.

The Committee recommends the following practice for the purpose of fixing the responsibility and providing for adequate supervision during construction:

(*a*) Before work is commenced, complete plans and specifications should be prepared, giving the dead and live loads,

wind and impact, if any, and working stresses, showing the general arrangement and all details. The plans should show the size, length, location of points of bending, and exact position of all reinforcement, including stirrups, ties, hooping and splicing.

(*b*) The specifications should state the qualities of the materials and the proportions in which they are to be used.

(*c*) The strength which the concrete is expected to attain after a definite period should be stated in the specifications.

(*d*) Inspection during construction should be made by competent inspectors selected by and under the supervision of the engineer, and should cover the following:

1. Materials.
2. Construction and erection of the forms and supports.
3. Sizes, shapes, arrangement, position and fastening of the reinforcement.
4. Proportioning, mixing, consistency, and placing of the concrete.
5. Strength of the concrete by tests of standard test pieces made on the work.
6. Whether the concrete is sufficiently hardened before the forms and supports are removed.
7. Protection from injury of all parts of the structure.
8. Comparison of dimensions of all parts of the finished structure with the plans.

(*e*) Load tests on portions of the finished structure should be made where there is reasonable suspicion that the work has not been properly performed, or that, through influences of some kind, the strength has been impaired, or where there is any doubt as to the sufficiency of the design. The loading should be carried to such a point that the calculated stresses under such loading shall be one and three-quarters times the allowed working stresses, and such loads should cause no injurious permanent deformations. Load tests should not be made before the concrete has been in place sixty days.

Destructive Agencies

(*a*) *Corrosion of Metal Reinforcement* — Tests and experience indicate that steel sufficiently embedded in good concrete is well protected against corrosion, no matter whether located above or below water level. It is recommended that such protection be not less than 1-inch in thickness. If the concrete is porous so as to be readily permeable by water, as when the concrete is laid with a very dry consistency, the metal may corrode on account of the presence of moisture and air.

(*b*) *Electrolysis* — The experimental data available on this subject seem to show that while reinforced concrete structures may, under certain conditions, be injured by the flow of electric current in either direction between the reinforcing material and the concrete, such injury is generally to be expected only where voltages are considerably higher than those which usually occur in concrete structures in practice. If the iron be positive, trouble may manifest itself by corrosion of the iron accompanied by cracking of the concrete, and, if the iron be negative, there may be a softening of the concrete near the surface of the iron, resulting in a destruction of the bond. The former, or anode effect, decreases much more rapidly than the voltage, and almost if not quite disappears at voltages that are most likely to be encountered in practice. The cathode effect, on the other hand, takes place even under very low voltages, and is therefore more important from a practical standpoint than that of the anode.

Structures containing salt or calcium chloride, even in very small quantities, are very much more susceptible to the effects of electric currents than normal concrete, the anode effect progressing much more rapidly in the presence of chlorine, and the cathode effect being greatly increased by the presence of an alkali metal.

There is great weight of evidence to show that normal reinforced concrete structures free from salt are in very little danger under most practical conditions, while non-reinforced concrete structures are practically immune from electrolysis troubles.

(*c*) *Sea Water* — The data available concerning the effect of sea water on concrete or reinforced concrete are limited and

inconclusive. Sea walls out of the range of frost action have been standing for many years without apparent injury. In many places serious disintegration has taken place. This has occurred chiefly between low and high tide levels and is due, evidently, in part to frost. Chemical action also appears to be indicated by the softening of the mortar. To effect the best resistance to sea water, the concrete must be proportioned, mixed and placed so as to prevent the penetration of sea water into the mass or through the joints. The aggregates should be carefully selected, graded and proportioned with the cement so as to secure the maximum possible density; the concrete should be thoroughly mixed; the joints between old and new work should be made watertight; and the concrete should be kept from exposure to sea water until it is thoroughly hard and impervious.

(*d*) *Acids*—Dense concrete thoroughly hardened is affected appreciably only by acids which seriously injure other materials. Substances like manure that contain acids may injuriously affect green concrete, but do not affect concrete that is thoroughly hardened.

(*e*) *Oils* — Concrete is unaffected by such mineral oils as petroleum and ordinary engine oils. Oils which contain fatty acids produce injurious effects, forming compounds with the lime which may result in a disintegration of the concrete in contact with them.

(*f*) *Alkalies* — The action of alkalies on concrete is problematical. In the reclamation of arid land where the soil is heavily charged with alkaline salts it has been found that concrete, stone, brick, iron and other materials are injured under certain conditions. It would seem that at the level of the ground water in an extremely dry atmosphere such structures are disintegrated, through the rapid crystallization of the alkaline salts, resulting from the alternate wetting and drying of the surface. Such destructive action can be prevented by the use of a protective coating and is minimized by securing a dense concrete.

Chapter III

Materials

The quality of all the materials is of paramount importance. The cement and also the aggregates should be subject to definite requirements and tests.

Cement

There are available for construction purposes Portland, Natural and Puzzolan or Slag cements.

(*a*) *Portland Cement* is the product obtained by finely pulverizing clinker produced by calcining to incipient fusion, an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum.

It has a definite chemical composition varying within comparatively narrow limits.

Portland cement only should be used in reinforced concrete construction or in any construction that will be subject to shocks, vibrations, or stresses other than direct compression.

(*b*) *Natural Cement* is the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

Although the limestone must have a certain composition, this composition may vary within much wider limits than in the case of Portland cement. Natural cement does not develop its strength as quickly nor is it as uniform in composition as Portland cement.

Natural cement may be used in massive masonry where weight rather than strength is the essential feature.

Where economy is the governing factor a comparison may be made between the use of natural cement and a leaner mixture of Portland cement that will develop the same strength.

(*c*) *Puzzolan or Slag Cement* is the product resulting from finely pulverizing a mechanical mixture of granulated basic blast-furnace slag and hydrated lime.

Puzzolan cement is not nearly as strong, uniform, or reliable as Portland or natural cement, is not used extensively, and never in important work; it should be used only for unimportant foundation work underground where it is not exposed to air or running water.

(*d*) *Specifications* — The cement should meet the requirements of the specifications and methods of tests for Portland cement, which are the result of the joint labors of special committees of the American Society of Civil Engineers, American Society for Testing Materials, American Railway Engineering Association, and other affiliated organizations, and the United States Government.

Aggregates

Extreme care should be exercised in selecting the aggregates for mortar and concrete, and careful tests made of the materials for the purpose of determining the quality and grading necessary to secure maximum density[1] or a minimum percentage of voids. Bank gravel should be separated by screening into fine and coarse aggregates and then used in the proportions to be determined by density tests.

(*a*) *Fine Aggregate* should consist of sand, or the screenings of gravel or crushed stone, graded from fine to coarse, and passing when dry a screen having ¼-inch diameter holes;[2] it preferably should be of siliceous material, and not more than 30 per cent by weight, should pass a sieve having 50 meshes per linear inch; it should be clean, and free from soft particles, lumps of clay, vegetable loam or other organic matter.

Fine aggregate should always be tested for strength. It should be of such quality that mortar composed of one part Portland Cement and three parts fine aggregate by weight when made into briquettes, prisms or cylinders will show a tensile or compressive strength, at an age of not less than 7 days, at least equal to the strength of 1:3 mortar of the same consistency made with the same cement and standard Ottawa

[1] A convenient coefficient of density is the ratio of the sum of the volumes of solid particles contained in a unit volume to the total unit volume.

[2] If the dividing size between the fine and coarse aggregate is less or greater than one-quarter inch, allowance should be made in grading and proportioning.

sand.[1] If the aggregate be of poorer quality, the proportion of cement should be increased to secure the desired strength. If the strength developed by the aggregate in the 1:3 mortar is less than 70 per cent of the strength of the Ottawa-sand mortar, the material should be rejected. In testing aggregates care should be exercised to avoid the removal of any coating on the grains, which may affect the strength; bank sands should not be dried before being made into mortar, but should contain natural moisture. The percentage of moisture may be determined upon a separate sample for correcting weight. From 10 to 40 per cent more water may be required in mixing bank or artificial sands than for standard Ottawa sand to produce the same consistency.

(*b*) *Coarse Aggregate* should consist of gravel or crushed stone which is retained on a screen having ¼-inch diameter holes, and should be graded from the smallest to the largest particles; it should be clean, hard, durable, and free from all deleterious matter. Aggregates containing dust and soft, flat or elongated particles, should be excluded. The Committee does not feel warranted in recommending the use of blast furnace slag as an aggregate, in the absence of adequate data as to its value, especially in reinforced concrete construction. No satisfactory specifications or methods of inspection have been developed that will control its uniformity and ensure the durability of the concrete in which it is used.

The aggregate must be small enough to produce with the mortar a homogeneous concrete of sluggish consistency which will pass readily between and easily surround the reinforcement and fill all parts of the forms. The maximum size of particles is variously determined for different types of construction from that which will pass a ½-inch ring to that which will pass a 1½-inch ring.

For concrete in large masses the size of the coarse aggregate may be increased, as a large aggregate produces a stronger

[1] A natural sand obtained at Ottawa, Illinois, passing a screen having 20 meshes and retained on a screen having 30 meshes per linear inch; prepared and furnished by the Ottawa Silica Company, for 2 cents per pound f. o. b. cars, Ottawa, Illinois.

concrete than a fine one; however, it should be noted that the danger of separation from the mortar becomes greater as the size of the coarse aggregate increases.

Cinder concrete should not be used for reinforced concrete structures except in floor slabs not exceeding 8 foot span. It also may be used for fire protection purposes where not required to carry loads. The cinders used should be composed of hard, clean, vitreous clinker, free from sulphides, unburned coal or ashes.

Water

The water used in mixing concrete should be free from oil, acid, alkali, or organic matter.

Metal Reinforcement

The Committee recommends as a suitable material for reinforcement, steel of structural grade filling the requirements of the Specifications for Billet-Steel Concrete Reinforcement Bars of the American Society for Testing Materials.

For reinforcing slabs, small beams or minor details, or for reinforcing for shrinkage and temperature stresses, steel wire, expanded metal, or other reticulated steel may be used, with the unit stresses hereinafter recommended.

The reinforcement should be free from flaking rust, scale, or coatings of any character which would tend to reduce or destroy the bond.

Chapter IV

Mixing and Placing

Proportions

The materials should be carefully selected, of uniform quality, and proportioned with a view to securing as nearly as possible a maximum density, which is obtained by grading the aggregates so that the smaller particles fill the spaces between the larger thus reducing the voids in the aggregate to the minimum.

(*a*) *Unit of Measure* — The measurement of the fine and coarse aggregates should be by loose volume. The unit of measure should be a bag of cement, containing 94 lb. net, which should be considered the equivalent of one cubic foot.

(*b*) *Relation of Fine and Coarse Aggregates* — The fine and coarse aggregates should be used in such proportions as will secure maximum density. These proportions should be carefully determined by density experiments and the grading of the fine and coarse aggregates should be uniformly maintained, or the proportions changed to meet the varying sizes.

(*c*) *Relation of Cement and Aggregates* — For reinforced concrete construction, one part of cement to a total of six parts of fine and coarse aggregates measured separately should generally be used. For columns, richer mixtures are preferable. In massive masonry or rubble concrete a mixture of 1 : 9 or even 1 : 12 may be used.

These proportions should be determined by the strength or other qualities required in the construction at the critical period of use. Experience and judgment based on observation and tests of similar conditions in similar localities are excellent guides as to the proper proportions for any particular case.

In important construction, advance tests should be made on concrete composed of the materials to be used in the work. These tests should be made by standardized methods to obtain uniformity in mixing, proportioning and storage, and in case the results do not conform to the requirements of the work, aggregates of a better quality or more cement should be used to obtain the desired quality of concrete.

Mixing

The mixing of concrete should be thorough, and continue until the mass is uniform in color and homogeneous. As the maximum density and greatest strength of a given mixture depend largely on thorough and complete mixing, it is essential that this part of the work should receive special attention and care. Inasmuch as it is difficult to determine, by visual inspection, whether the concrete is uniformly mixed, especially where aggregates having the color of cement are used, it is essential that the mixing should occupy a definite period of time. The minimum time will depend on whether the mixing is done by machine or hand.

(*a*) *Measuring Ingredients*—Methods of measurement of the various ingredients should be used which will secure at all times separate and uniform measurements of cement, fine aggregate, coarse aggregate, and water.

(*b*) *Machine Mixing* — The mixing should be done in a batch machine mixer of a type which will ensure the uniform distribution of the materials throughout the mass, and should continue for the minimum time of one and one-half minutes after all the ingredients are assembled in the mixer. For mixers of two or more cubic yards capacity, the minimum time of mixing should be two minutes. Since the strength of the concrete is dependent upon thorough mixing, a longer time than this minimum is preferable. It is desirable to have the mixer equipped with an attachment for automatically locking the discharging device so as to prevent the emptying of the mixer until all the materials have been mixed together for the minimum time required after they are assembled in the mixer. Means should be provided to prevent aggregates being added after the mixing has commenced. The mixer should also be equipped with water storage, and an automatic measuring device which can be locked is desirable. It is also desirable to equip the mixer with a device recording the revolutions of the drum. The number of revolutions should be so regulated as to give at the periphery of the drum a uniform speed; about 200 ft. per minute seems to be the best speed in the present state of the art.

(*c*) *Hand Mixing* — Hand mixing should be done on a watertight platform and especial precautions taken after the water has been added, to turn all the ingredients together at least six times, and until the mass is homogeneous in appearance and color.

(*d*) *Consistency* — The materials should be mixed wet enough to produce a concrete of such a consistency as will flow sluggishly into the forms and about the metal reinforcement when used, and which, at the same time, can be conveyed from the mixer to the forms without separation of the coarse aggre-

gate from the mortar. The quantity of water is of the greatest importance in securing concrete of maximum strength and density; too much water is as objectionable as too little.

(*e*) *Retempering* — The remixing of mortar or concrete that has partly set should not be permitted.

Placing Concrete

(*a*) *Methods* — Concrete after the completion of the mixing should be conveyed rapidly to the place of final deposit; under no circumstances should concrete be used that has partly set.

Concrete should be deposited in such a manner as will permit the most thorough compacting, such as can be obtained by working with a straight shovel or slicing tool kept moving up and down until all the ingredients are in their proper place. Special care should be exercised to prevent the formation of laitance; where laitance has formed it should be removed, since it lacks strength, and prevents a proper bond in the concrete.

Before depositing concrete, the reinforcement should be carefully placed in accordance with the plans. It is essential that adequate means be provided to hold it in its proper position until the concrete has been deposited and compacted; care should be taken that the forms are substantial and thoroughly wetted (except in freezing weather) or oiled and that the space to be occupied by the concrete is free from debris. When the placing of concrete is suspended, all necessary grooves for joining future work should be made before the concrete has set.

When work is resumed, concrete previously placed should be roughened, cleansed of foreign material and laitance, thoroughly wetted and then slushed with a mortar consisting of one part Portland cement and not more than two parts fine aggregate.

The surfaces of concrete exposed to premature drying should be kept covered and wet for a period of at least seven days.

Where concrete is conveyed by spouting, the plant should be of such a size and design as to ensure a practically continuous stream in the spout. The angle of the spout with the horizontal should be such as to allow the concrete to flow without a separation of the ingredients; in general an angle of about 27 degrees or one vertical to two horizontal is good practice. The spout should be thoroughly flushed with water before and after each run. The delivery from the spout should be as close as possible to the point of deposit. Where the discharge must be intermittent, a hopper should be provided at the bottom. Spouting through a vertical pipe is satisfactory when the flow is continuous; when it is unchecked and discontinuous it is highly objectionable unless the flow is checked by baffle plates.

(*b*) *Freezing Weather* — Concrete should not be mixed or deposited at a freezing temperature, unless special precautions are taken to prevent the use of materials covered with ice crystals or containing frost, and to prevent the concrete from freezing before it has set and sufficiently hardened.

As the coarse aggregate forms the greater portion of the concrete, it is particularly important that this material be warmed to well above the freezing point.

The enclosing of a structure and the warming of the space inside the enclosure is recommended, but the use of salt to lower the freezing point is not recommended.

(*c*) *Rubble Concrete* — Where the concrete is to be deposited in massive work, its value may be improved and its cost materially reduced by the use of clean stones, saturated with water, thoroughly embedded in and entirely surrounded by concrete.

(*d*) *Under Water* — In placing concrete under water it is essential to maintain still water at the place of deposit. With careful inspection the use of tremies, properly designed and operated, is a satisfactory method of placing concrete through water. The concrete should be mixed very wet (more so than is ordinarily permissible) so that it will flow readily through the tremie and into place with practically a level surface.

The coarse aggregate should be smaller than ordinarily used, and never more than 1 inch in diameter. The use of gravel facilitates mixing and assists the flow. The mouth of the tremie should be buried in the concrete so that it is at all times entirely sealed and the surrounding water prevented from forcing itself into the tremie; the concrete will then discharge without coming in contact with the water. The tremie should be suspended so that it can be lowered quickly when it is necessary either to choke off or prevent too rapid flow; the lateral flow preferably should be not over 15 feet.

The flow should be continuous in order to produce a monolithic mass and to prevent the formation of laitance in the interior.

In case the flow is interrupted it is important that all laitance be removed before proceeding with the work.

In large structures it may be necessary to divide the mass of concrete into several small compartments or units, to permit the continuous filling of each one. With proper care it is possible in this manner to obtain as good results under water as in the air.

A less desirable method is the use of the drop bottom bucket. Where this method is used, the bottom of the bucket should be released when in contact with the surface of the place of deposit.

Chapter V

Forms

Forms should be substantial and unyielding, in order that the concrete may conform to the design, and be sufficiently tight to prevent the leakage of mortar.

It is vitally important to allow sufficient time for the proper hardening of the concrete, which should be determined by careful inspection before the forms are removed.

Many conditions affect the hardening of concrete, and the proper time for the removal of the forms should be determined by some competent and responsible person.

It may be stated in a general way that forms should remain in place longer for reinforced concrete than is required for plain or massive concrete, and longer for horizontal than is required for vertical members.

In general it may be considered that concrete has hardened sufficiently when it has a distinctive ring under the blow of a hammer, but this test is not reliable, if there is a possibility that the concrete is frozen.

Chapter VI

Details of Construction

Joints

(*a*) *In Concrete* — It is desirable to cast an entire structure at one operation, but as this is not always possible, especially in large structures, it is necessary to stop the work at some convenient point. This should be selected so that the resulting joint may have the least possible effect on the strength of the structure. It is therefore recommended that the joint in columns be made flush with the lower side of the girders, or in flat slab construction at the bottom of the flare of the column head; that the joints in girders be at a point midway between supports, unless a beam intersect a girder at this point, in which case the joint should be offset a distance equal to twice the width of the beam; and that the joints in the members of a floor system should in general be made at or near the center of the span.

Joints in columns should be perpendicular to the axis, and in girders, beams, and floor slabs, perpendicular to the plane of their surfaces. When it is necessary to provide for shear at right angles to the axis, it is permissible to incline the plane of the joint as much as 30 degrees from the perpendicular. Joints in arch rings should be on planes as nearly radial as practicable.

Before placing the concrete on top of a freshly poured column a period of at least two hours should be allowed for the settlement and shrinkage.

Shrinkage and contraction joints may be necessary to concentrate cracks due to temperature in smooth even lines. The

number of these joints which should be determined and provided for in the design will depend on the range of temperature to which the concrete will be subjected, and on the amount and position of the reinforcement. In massive work, such as retaining walls, abutments, etc., built without reinforcement, contraction joints should be provided, at intervals of from 25 to 50 feet and with reinforcement from 50 to 80 feet; the smaller the height and thickness, the closer the spacing. The joints should be tongued and grooved to maintain the alignment in case of unequal settlement. A groove may be formed in the surface as a finish to vertical joints.

Shrinkage and contraction joints should be lubricated by an application of petroleum oil or a similar material to permit a free movement when the concrete expands or contracts.

The movement of the joint due to expansion and contraction may be facilitated by the insertion of a sheet of copper, zinc, or even tarred paper.

(*b*) *In Reinforcement* — Wherever it is necessary to splice tension reinforcement the length of lap should be determined on the basis of the safe bond stress, the stress in the bar and the shearing resistance of the concrete at the point of splice; or a connection should be made between the bars of sufficient strength to carry the stress. Splices at points of maximum stress in tension should be avoided. In columns, bars more than ¾-inch in diameter not subject to tension should have their ends properly squared and butted together in suitable sleeves; smaller bars may be lapped as indicated for tension reinforcement. At foundations, bearing plates should be provided for supporting the bars, or the bars may be carried into the footing a sufficient distance to transmit the stress in the steel to the concrete by means of the bearing and the bond resistance. In no case should reliance be placed upon the end bearing of bars on concrete.

Shrinkage and Temperature Changes

The stresses resulting from shrinkage due to hardening and contraction from temperature changes are important in monolithic construction, and unless cared for in the design

will produce objectionable cracks; cracks cannot be entirely prevented but the effects can be minimized.

Large cracks, produced by quick hardening or wide ranges of temperature, can be broken up to some extent into small cracks by placing reinforcement in the concrete; in long, continuous lengths of concrete, it is better to provide shrinkage joints at points in the structure where they will do little or no harm. Reinforcement permits longer distances between shrinkage joints than when no reinforcement is used.

Provision for shrinkage should be made where small or thin masses are joined to larger or thicker masses; at such places the use of fillets similar to those used in metal castings, but proportionally larger, is recommended.

Shrinkage cracks are likely to occur at points where fresh concrete is joined to that which is set, and hence in placing the concrete, construction joints should be made, as described in Chapter VI, or if possible, at points where joints would naturally occur in dimension stone masonry.

Fireproofing

Concrete, because incombustible and of a low rate of heat conductivity, is highly efficient and admirably adapted for fireproofing purposes. This has been demonstrated by experience and tests.

The dehydration of concrete probably begins at about 500° F. and is completed at about 900° F., but experience indicates that the volatilization of the water absorbs heat from the surrounding mass, which, together with the resistance of the air cells, tends to increase the heat resistance of the concrete, so that the process of dehydration is very much retarded. The concrete that is actually affected by fire and remains in position affords protection to that beneath it.

The thickness of the protective coating should be governed by the intensity and duration of a possible fire and the rate of heat conductivity of the concrete. The question of the rate of heat conductivity of concrete is one which requires further study and investigation before a definite rate for different classes of concrete can be fully established. However, for ordi-

nary conditions it is recommended that the metal be protected by a minimum of 2 inches of concrete on girders and columns, $1\frac{1}{2}$ inches on beams, and 1 inch on floor slabs.

Where fireproofing is required and not otherwise provided in monolithic concrete columns, it is recommended that the concrete to a depth of $1\frac{1}{2}$ inches be considered as protective covering and not included in the effective section.

The corners of columns, girders, and beams should be beveled or rounded, as a sharp corner is more seriously affected by fire than a round one; experience shows that round columns are more fire resistive than square.

Waterproofing

Many expedients have been resorted to for rendering concrete impervious to water. Experience shows, however, that when mortar or concrete is proportioned to obtain the greatest practicable density and is mixed to the proper consistency (Chapter IV), the resulting mortar or concrete is impervious under moderate pressure.

On the other hand, concrete of dry consistency is more or less pervious to water, and, though compounds of various kinds have been mixed with the concrete or applied as a wash to the surface, in an effort to offset this defect, these expedients have generally been disappointing, for the reason that many of these compounds have at best but temporary value, and in time lose their power of imparting impermeability to the concrete.

In the case of subways, long retaining walls and reservoirs, provided the concrete itself is impervious, cracks may be so reduced by horizontal and vertical reinforcement properly proportioned and located, that they will be too minute to permit leakage, or will be closed by infiltration of silt.

Asphaltic or coal-tar preparations applied either as a mastic or as a coating on felt or cloth fabric, are used for waterproofing, and should be proof against injury by liquids or gases.

For retaining and similar walls in direct contact with the earth, the application of one or two coatings of hot coal-tar pitch, following a painting with a thin wash of coal tar dissolved

in benzol, to the thoroughly dried surface of concrete is an efficient method of preventing the penetration of moisture from the earth.

Surface Finish

Concrete is a material of an individual type and should be used without effort at imitation of other building materials. One of the important problems connected with its use is the character of the finish of exposed surfaces. The desired finish should be determined before the concrete is placed, and the work conducted so as to facilitate securing it. The natural surface of the concrete in most structures is unobjectionable, but in others the marks of the forms and the flat dead surface are displeasing, making some special treatment desirable. A treatment of the surface which removes the film of cement and brings the aggregates of the concrete into relief, either by scrubbing with brushes and water before it is hard or by tooling it after it is hard, is frequently used to erase the form markings and break the monotonous appearance of the surface. Besides being more pleasing in immediate appearance such a surface is less subject to discoloration and hair cracking than is a surface composed of the cement that segregates against the forms, or one that is made by applying a cement wash. The aggregates can also be exposed by washing with hydrochloric acid diluted with from 6 to 10 parts of water. The plastering of surfaces should be avoided, for even if carefully done, it is liable to peel off under the action of frost or temperature changes.

Various effects in texture and in color can be obtained when the surface is to be scrubbed or tooled, by using aggregates of the desired size and color. For a fine grained texture a granolithic surface mixture can be made and placed against the face forms to a thickness of about 1 inch as the placing of the body of the concrete proceeds.

A smooth, even surface without form marks can be secured by the use of plastered forms, which in structures having many duplications of members can be used repeatedly; these are made in panels of expanded metal or wire mesh coated with plaster, and the joints made at edges, and closed with plaster of Paris.

Chapter VII

Design

Massive Concrete

In the design of massive or plain concrete, no account should be taken of the tensile strength of the material, and sections should usually be proportioned so as to avoid tensile stresses except in slight amounts to resist indirect stresses. This will generally be accomplished in the case of rectangular shapes if the line of pressure is kept within the middle third of the section, but in very large structures, such as high masonry dams, a more exact analysis may be required. Structures of massive concrete are able to resist unbalanced lateral forces by reason of their weight; hence the element of weight rather than strength often determines the design. A leaner and relatively cheap concrete, therefore, will often be suitable for massive concrete structures.

It is desirable generally to provide joints at intervals to localize the effect of contraction (Chapter VI).

Massive concrete is suitable for dams, retaining walls, and piers in which the ratio of length to least width is relatively small. Under ordinary conditions this ratio should not exceed four. It is also suitable for arches of moderate span.

Reinforced Concrete

The use of metal reinforcement is particularly advantageous in members such as beams in which both tension and compression exist, and in columns where the principal stresses are compressive and where there also may be cross-bending. Therefore the theory of design here presented relates mainly to the analysis of beams and columns.

General Assumptions

(*a*) *Loads* — The forces to be resisted are those due to:

1. *The dead load*, which includes the weight of the structure and fixed loads and forces.
2. *The live load*, or the loads and forces which are variable. The dynamic effect of the live load will often require consideration. Allowance for the latter is preferably made by a proportionate increase in either the live load or the live load

stresses. The working stresses hereinafter recommended are intended to apply to the equivalent static stresses thus determined.

In the case of high buildings the live load on columns may be reduced in accordance with the usual practice.

(*b*) *Lengths of Beams and Columns* — The span length for beams and slabs simply supported should be taken as the distance from center to center of supports, but need not be taken to exceed the clear span plus the depth of beam or slab. For continuous or restrained beams built monolithically into supports the span length may be taken as the clear distance between faces of supports. Brackets should not be considered as reducing the clear span in the sense here intended, except that when brackets which make an angle of 45 degrees or more with the axis of a restrained beam are built monolithically with the beam, the span may be measured from the section where the combined depth of beam and bracket is at least one-third more than the depth of the beam. Maximum negative moments are to be considered as existing at the end of the span as here defined.

When the depth of a restrained beam is greater at its ends than at midspan and the slope of the bottom of the beam at its ends makes an angle of not more than 15 degrees with the direction of the axis of the beam at midspan, the span length may be measured from face to face of supports.

The length of columns should be taken as the maximum unstayed length.

(*c*) *Stresses* — The following assumptions are recommended as a basis for calculations:

1. Calculations will be made with reference to working stresses and safe loads rather than with reference to ultimate strength and ultimate loads.

2. A plane section before bending remains plane after bending.

3. The modulus of elasticity of concrete in compression is constant within the usual limits of working stresses. The distribution of compressive stress in beams is therefore rectilinear.
4. In calculating the moment of resistance of beams the tensile stresses in the concrete are neglected.
5. The adhesion between the concrete and the reinforcement is perfect. Under compressive stress the two materials are therefore stressed in proportion to their moduli of elasticity.
6. The ratio of the modulus of elasticity of steel to the modulus of elasticity of concrete is taken at 15 except as modified in Chapter VIII.
7. Initial stress in the reinforcement due to contraction or expansion of the concrete is neglected.

It is recognized that some of the assumptions given herein are not entirely borne out by experimental data. They are given in the interest of simplicity and uniformity, and variations from exact conditions are taken into account in the selection of formulas and working stresses.

The deflection of a beam depends upon the strength and stiffness developed throughout its length. For calculating deflection a value of 8 for the ratio of the moduli will give results corresponding approximately with the actual conditions.

T-Beams

In beam and slab construction an effective bond should be provided at the junction of the beam and slab. When the principal slab reinforcement is parallel to the beam, transverse reinforcement should be used extending over the beam and well into the slab.

The slab may be considered an integral part of the beam, when adequate bond and shearing resistance between slab and web of beam is provided, but its effective width shall be determined by the following rules:

(*a*) It shall not exceed one-fourth of the span length of the beam;

(*b*) Its overhanging width on either side of the web shall not exceed six times the thickness of the slab.

In the design of continuous T-beams, due consideration should be given to the compressive stress at the support.

Beams in which the T-form is used only for the purpose of providing additional compression area of concrete should preferably have a width of flange not more than three times the width of the stem and a thickness of flange not less than one-third of the depth of the beam. Both in this form and in the beam and slab form the web stresses and the limitations in placing and spacing the longitudinal reinforcement will probably be controlling factors in design.

Floor Slabs Supported Along Four Sides

Floor slabs having the supports extending along the four sides should be designed and reinforced as continuous over the supports. If the length of the slab exceeds 1.5 times its width the entire load should be carried by transverse reinforcement.

For uniformly distributed loads on square slabs, one-half the live and dead load may be used in the calculations of moment to be resisted in each direction. For oblong slabs, the length of which is not greater than one and one-half times their width, the moment to be resisted by the transverse reinforcement may be found by using a proportion of the live and dead load equal to that given by the formula $r = \frac{l}{b} - 0.5$, where l=length and b=breadth of slab. The longitudinal reinforcement should then be proportioned to carry the remainder of the load.

In placing reinforcement in such slabs account may well be taken of the fact that the bending moment is greater near the center of the slab than near the edges. For this purpose two-thirds of the previously calculated moments may be assumed as carried by the center half of the slab and one-third by the outside quarters.

Loads carried to beams by slabs which are reinforced in two directions will not be uniformly distributed to the supporting beams and the distribution will depend on the relative

stiffness of the slab and the supporting beams. The distribution which may be expected ordinarily is a variation of the load in the beam in accordance with the ordinates of a parabola, having its vertex at the middle of the span. For any given design, the probable distribution should be ascertained and the moments in the beam calculated accordingly.

Continuous Beams and Slabs

When the beam or slab is continuous over its supports, reinforcement should be fully provided at points of negative moment, and the stresses in concrete recommended in Chapter VIII, should not be exceeded. In computing the positive and negative moments in beams and slabs continuous over several supports, due to uniformly distributed loads, the following rules are recommended:

(*a*) For floor slabs the bending moments at center and at support should be taken at $\frac{wl^2}{12}$ for both dead and live loads, where w represents the load per linear unit and l the span length.

(*b*) For beams the bending moment at center and at support for interior spans should be taken at $\frac{wl^2}{12}$, and for end spans it should be taken at $\frac{wl^2}{10}$ for center and interior support, for both dead and live loads.

(*c*) In the case of beams and slabs continuous for two spans only, with their ends restrained, the bending moment both at the central support and near the middle of the span should be taken at $\frac{wl^2}{10}$.

(*d*) At the ends of continuous beams the amount of negative moment which will be developed in the beam will depend on the condition of restraint or fixedness, and this will depend on the form of construction used. In the ordinary cases a moment of $\frac{wl^2}{16}$ may be taken; for small beams running into heavy columns this should be increased, but not to exceed $\frac{wl^2}{12}$.

For spans of unusual length, or for spans of materially

unequal length, more exact calculations should be made. Special consideration is also required in the case of concentrated loads.

Even if the center of the span is designed for a greater bending moment than is called for by (*a*) or (*b*), the negative moment at the support should not be taken as less than the values there given.

Where beams are reinforced on the compression side, the steel may be assumed to carry its proportion of stress in accordance with the ratio of moduli of elasticity, Chapter VIII. Reinforcing bars for compression in beams should be straight and should be two diameters in the clear from the surface of the concrete. For the positive bending moment, such reinforcement should not exceed 1 per cent of the area of the concrete. In the case of cantilever and continuous beams, tensile and compressive reinforcement over supports should extend sufficiently beyond the support and beyond the point of inflection to develop the requisite bond strength.

In construction made continuous over supports it is important that ample foundations should be provided; for unequal settlements are liable to produce unsightly if not dangerous cracks. This effect is more likely to occur in low structures.

Girders, such as wall girders, which have beams framed into one side only, should be designed to resist torsional moment arising from the negative moment at the end of the beam.

Bond Strength and Spacing of Reinforcement

Adequate bond strength should be provided. The formula hereinafter given for bond stresses in beams is for straight longitudinal bars. In beams in which a portion of the reinforcement is bent up near the end, the bond stress at places, in both the straight bars and the bent bars, will be considerably greater than for all the bars straight, and the stress at some point may be several times as much as that found by considering the stress to be uniformly distributed along the bar. In restrained and cantilever beams full tensile stress exists in the reinforcing bars at the point of support and the bars should be anchored in the support sufficiently to develop this stress.

In case of anchorage of bars, an additional length of bar should be provided beyond that found on the assumption of uniform bond stress, for the reason that before the bond resistance at the end of the bar can be developed the bar may have begun to slip at another point and "running" resistance is less than the resistance before slip begins.

Where high bond resistance is required, the deformed bar is a suitable means of supplying the necessary strength. But it should be recognized that even with a deformed bar initial slip occurs at early loads, and that the ultimate loads obtained in the usual tests for bond resistance may be misleading. Adequate bond strength throughout the length of a bar is preferable to end anchorage, but, as an additional safeguard, such anchorage may properly be used in special cases. Anchorage furnished by short bends at a right angle is less effective than by hooks consisting of turns through 180 degrees.

The lateral spacing of parallel bars should be not less than three diameters from center to center, nor should the distance from the side of the beam to the center of the nearest bar be less than two diameters. The clear spacing between two layers of bars should be not less than 1 inch. The use of more than two layers is not recommended, unless the layers are tied together by adequate metal connections, particularly at and near points where bars are bent up or bent down. Where more than one layer is used at least all bars above the lower layer should be bent up and anchored beyond the edge of the support.

Diagonal Tension and Shear

When a reinforced concrete beam is subjected to flexural action, diagonal tensile stresses are set up. A beam without web reinforcement will fail if these stresses exceed the tensile strength of the concrete. When web reinforcement, made up of stirrups or of diagonal bars secured to the longitudinal reinforcement, or of longitudinal reinforcing bars bent up at several points, is used, new conditions prevail, but even in this case at the beginning of loading the diagonal tension developed is taken principally by the concrete, the deformations which are developed in the concrete permitting but little stress to be taken

by the web reinforcement. When the resistance of the concrete to the diagonal tension is overcome at any point in the depth of the beam, greater stress is at once set up in the web reinforcement.

For homogeneous beams the analytical treatment of diagonal tension is not very complex — the diagonal tensile stress is a function of the horizontal and vertical shearing stresses and of the horizontal tensile stress at the point considered, and as the intensity of these three stresses varies from the neutral axis to the remotest fiber, the intensity of the diagonal tension will be different at different points in the section, and will change with different proportionate dimensions of length to depth of beam. For the composite structure of reinforced concrete beams, an analysis of the web stresses, and particularly of the diagonal tensile stresses, is very complex; and when the variations due to a change from no horizontal tensile stress in the concrete at remotest fiber to the presence of horizontal tensile stress at some point below the neutral axis are considered, the problem becomes more complex and indefinite. Under these circumstances, in designing recourse is had to the use of the calculated vertical shearing stress as a means of comparing or measuring the diagonal tensile stresses developed, it being understood that the vertical shearing stress is not the numerical equivalent of the diagonal tensile stress, and that there is not even a constant ratio between them. It is here recommended that the maximum vertical shearing stress in a section be used as the means of comparison of the resistance to diagonal tensile stress developed in the concrete in beams not having web reinforcement.

Even after the concrete has reached its limit of resistance to diagonal tension, if the beam has web reinforcement, conditions of beam action will continue to prevail, at least through the compression area, and the web reinforcement will be called on to resist only a part of the web stresses. From experiments with beams it is concluded that it is safe practice to use only two-thirds of the external vertical shear in making calculations

of the stresses that come on stirrups, diagonal web pieces, and bent-up bars, and it is here recommended for calculations in designing that two-thirds of the external vertical shear be taken as producing stresses in web reinforcement.

It is well established that vertical members attached to or looped about horizontal members, inclined members secured to horizontal members in such a way as to insure against slip, and the bending of a part of the longitudinal reinforcement at an angle, will increase the strength of a beam against failure by diagonal tension, and that a well-designed and well-distributed web reinforcement may under the best conditions increase the total vertical shear carried to a value as much as three times that obtained when the bars are all horizontal and no web reinforcement is used.

When web reinforcement comes into action as the principal tension web resistance, the bond stresses between the longitudinal bars and the concrete are not distributed as uniformly along the bars as they otherwise would be, but tend to be concentrated at and near stirrups, and at and near the points where bars are bent up. When stirrups are not rigidly attached to the longitudinal bars, and the proportioning of bars and stirrup spacing is such that local slip of bars occur at stirrups, the effectiveness of the stirrups is impaired, though the presence of stirrups still gives an element of toughness against diagonal tension failure.

Sufficient bond resistance between the concrete and the stirrups or diagonals must be provided in the compression area of the beam.

The longitudinal spacing of vertical stirrups should not exceed one-half the depth of beam, and that of inclined members should not exceed three-fourths of the depth of beam.

Bending of longitudinal reinforcing bars at an angle across the web of the beam may be considered as adding to diagonal tension resistance for a horizontal distance from the point of bending equal to three-fourths of the depth of beam. Where the bending is made at two or more points, the distance be-

tween points of bending should not exceed three-fourths of the depth of the beam. In the case of a restrained beam the effect of bending up a bar at the bottom of the beam in resisting diagonal tension may not be taken as extending beyond a section at the point of inflection, and the effect of bending down a bar in the region of negative moment may be taken as extending from the point of bending down of bar nearest the support to a section not more than three-fourths of the depth of beam beyond the point of bending down of bar farthest from the support but not beyond the point of inflection. In case stirrups are used in the beam away from the region in which the bent bars are considered effective, a stirrup should be placed not farther than a distance equal to one-fourth the depth of beam from the limiting sections defined above. In case the web resistance required through the region of bent bars is greater than that furnished by the bent bars, sufficient additional web reinforcement in the form of stirrups or attached diagonals should be provided. The higher resistance to diagonal tension stresses given by unit frames having the stirrups and bent-up bars securely connected together both longitudinally and laterally is worthy of recognition. It is necessary that a limit be placed on the amount of shear which may be allowed in a beam; for when web reinforcement sufficiently efficient to give very high web resistance is used, at the higher stresses the concrete in the beam becomes checked and cracked in such a way as to endanger its durability as well as its strength.

The section to be taken as the critical section in the calculation of shearing stresses will generally be the one having the maximum vertical shear, though experiments show that the section at which diagonal tension failures occur is not just at a support even though the shear at the latter point be much greater.

In the case of restrained beams, the first stirrup or the point of bending down of bar should be placed not farther than one-half of the depth of beam away from the face of the support.

It is important that adequate bond strength or anchorage be provided to develop fully the assumed strength of all web reinforcement.

Low bond stresses in the longitudinal bars are helpful in giving resistance against diagonal tension failures and anchorage of longitudinal bars at the ends of the beams or in the supports is advantageous.

It should be noted that it is on the tension side of a beam that diagonal tension develops in a critical way, and that proper connection should always be made between stirrups or other web reinforcement and the longitudinal tension reinforcement, whether the latter is on the lower side of the beam or on its upper side. Where negative moment exists, as is the case near the supports in a continuous beam, web reinforcement to be effective must be looped over or wrapped around or be connected with the longitudinal tension reinforcing bars at the top of the beam in the same way as is necessary at the bottom of the beam at sections where the bending moment is positive.

Inasmuch as the smaller the longitudinal deformations in the horizontal reinforcement are, the less the tendency for the formation of diagonal cracks, a beam will be strengthened against diagonal tension failure by so arranging and proportioning the horizontal reinforcement that the unit stresses at points of large shear shall be relatively low.

It does not seem feasible to make a complete analysis of the action of web reinforcement, and more or less empirical methods of calculation are therefore employed. Limiting values of working stresses for different types of web reinforcement are given in Chapter VIII. The conditions apply to cases commonly met in design. It is assumed that adequate bond resistance or anchorage of all web reinforcement will be provided.

When a flat slab rests on a column, or a column bears on a footing, the vertical shearing stresses in the slab or footing immediately adjacent to the column are termed punching shearing stresses. The element of diagonal tension, being a function of the bending moment as well as of shear, may be small in such cases, or may be otherwise provided for. For this reason the permissible limit of stress for punching shear

may be higher than the allowable limit when the shearing stress is used as a means of comparing diagonal tensile stress. The working values recommended are given in Chapter VIII.

Columns

By columns are meant compression members of which the ratio of unsupported length to least width exceeds about four, and which are provided with reinforcement of one of the forms hereafter described.

It is recommended that the ratio of unsupported length of column to its least width be limited to 15.

The effective area of hooped columns or columns reinforced with structural shapes shall be taken as the area within the circle enclosing the spiral or the polygon enclosing the structural shapes.

Columns may be reinforced by longitudinal bars; by bands, hoops, or spirals, together with longitudinal bars; or by structural forms which are sufficiently rigid to have value in themselves as columns. The general effect of closely spaced hooping is to greatly increase the toughness of the column and to add to its ultimate strength, but hooping has little effect on its behavior within the limit of elasticity. It thus renders the concrete a safer and more reliable material, and should permit the use of a somewhat higher working stress. The beneficial effects of toughening are adequately provided by a moderate amount of hooping, a larger amount serving mainly to increase the ultimate strength and the deformation possible before ultimate failure.

Composite columns of structural steel and concrete in which the steel forms a column by itself should be designed with caution. To classify this type as a concrete column reinforced with structural steel is hardly permissible, as the steel generally will take the greater part of the load. When this type of column is used, the concrete should not be relied upon to tie the steel units together nor to transmit stresses from one unit to another. The units should be adequately tied together by tie plates or lattice bars, which, together with other details,

such as splices, etc., should be designed in conformity with standard practice for structural steel. The concrete may exert a beneficial effect in restraining the steel from lateral deflection and also in increasing the carrying capacity of the column. The proportion of load to be carried by the concrete will depend on the form of the column and the method of construction. Generally, for high percentages of steel, the concrete will develop relatively low unit stresses, and caution should be used in placing dependence on the concrete.

The following recommendations are made for the relative working stresses in the concrete for the several types of columns:

(*a*) Columns with longitudinal reinforcement to the extent of not less than 1 per cent and not more than 4 per cent, and with lateral ties of not less than ¼-inch in diameter 12 inches apart, nor more than 16 diameters of the longitudinal bar: the unit stress recommended for axial compression, on concrete piers having a length not more than four diameters, in Chapter VIII.

(*b*) Columns reinforced with not less than 1 per cent and not more than 4 per cent of longitudinal bars and with circular hoops or spirals not less than 1 per cent of the volume of the concrete and as hereinafter specified: a unit stress 55 per cent higher than given for (*a*), provided the ratio of unsupported length of column to diameter of the hooped core is not more than 10.

The foregoing recommendations are based on the following conditions:

It is recommended that the minimum size of columns to which the working stresses may be applied be 12 inches out to out.

In all cases longitudinal reinforcement is assumed to carry its proportion of stress in accordance with the provisions of this chapter. The hoops or bands are not to be counted on directly as adding to the strength of the column.

Longitudinal reinforcement bars should be maintained straight, and should have sufficient lateral support to be securely held in place until the concrete has set.

Where hooping is used, the total amount of such reinforcement shall be not less than 1 per cent of the volume of the column, enclosed. The clear spacing of such hooping shall be not greater than one-sixth the diameter of the enclosed column and preferably not greater than one-tenth, and in no case more than 2½ inches. Hooping is to be circular and the ends of bands must be united in such a way as to develop their full strength. Adequate means must be provided to hold bands or hoops in place so as to form a column, the core of which shall be straight and well centered. The strength of hooped columns depends very much upon the ratio of length to diameter of hooped core, and the strength due to hooping decreases rapidly as this ratio increases beyond five. The working stresses recommended are for hooped columns with a length of not more than ten diameters of the hooped core.

The Committee has no recommendation to make for a formula for working stresses for columns longer than ten diameters.

Bending stresses due to eccentric loads, such as unequal spans of beams, and to lateral forces, must be provided for by increasing the section until the maximum stress does not exceed the values above specified. Where tension is possible in the longitudinal bars of the column, adequate connection between the ends of the bars must be provided to take this tension.

Reinforcing for Shrinkage and Temperature Stresses

When areas of concrete too large to expand and contract freely as a whole are exposed to atmospheric conditions, the changes of form due to shrinkage and to action of temperature are such that cracks may occur in the mass unless precautions are taken to distribute the stresses so as to prevent the cracks altogether or to render them very small. The distance apart of the cracks, and consequently their size, will be directly proportional to the diameter of the reinforcement and to the tensile strength of the concrete, and inversely proportional to the per-

centage of reinforcement and also to its bond resistance per unit of surface area. To be most effective, therefore, reinforcement (in amount generally not less than one-third of one per cent of the gross area) of a form which will develop a high bond resistance should be placed near the exposed surface and be well distributed. Where openings occur the area of cross-section of the reinforcement should not be reduced. The allowable size and spacing of cracks depends on various considerations, such as the necessity for water-tightness, the importance of appearance of the surface, and the atmospheric changes.

The tendency of concrete to shrink makes it necessary except where expansion is provided for, to thoroughly connect the component parts of the frame of articulated structures, such as floor and wall members in buildings, by the use of suitable reinforcing material. The amount of reinforcement for such connection should bear some relation to the size of the members connected, larger and heavier members requiring stronger connections. The reinforcing bars should be extended beyond the critical section far enough, or should be sufficiently anchored to develop their full tensile strength.

Flat Slab

The continuous flat slab reinforced in two or more directions and built monolithically with the supporting columns (without beams or girders) is a type of construction which is now extensively used and which has recognized advantages for certain types of structures as, for example, warehouses in which large, open floor space is desired. In its construction, there is excellent opportunity for inspecting the position of the reinforcement. The conditions attending depositing and placing of concrete are favorable to securing uniformity and soundness in the concrete. The recommendations in the following paragraphs relate to flat slabs extending over several rows of panels in each direction. Necessarily the treatment is more or less empirical.

The coefficients and moments given relate to uniformly distributed loads.

(*a*) *Column Capital* — It is usual in flat slab construction to enlarge the supporting columns at their top, thus forming column capitals. The size and shape of the column capital affect the strength of the structure in several ways. The moment of the external forces which the slab is called upon to resist is dependent upon the size of the capital; the section of the slab immediately above the upper periphery of the capital carries the highest amount of punching shear; and the bending moment developed in the column by an eccentric or unbalanced loading of the slab is greatest at the under surface of the slab. Generally the horizontal section of the column capital should be round or square with rounded corners. In oblong panels the section may be oval or oblong, with dimensions proportional to the panel dimensions. For computation purposes, the diameter of the column capital will be considered to be measured where its vertical thickness is at least 1½ inches, provided the slope of the capital below this point nowhere makes an angle with the vertical of more than 45 degrees. In case a cap is placed above the column capital, the part of this cap within a cone made by extending the lines of the column capital upward at the slope of 45 degrees to the bottom of the slab or dropped panel may be considered as part of the column capital in determining the diameter for design purposes. Without attempting to limit the size of the column capital for special cases, it is recommended that the diameter of the column capital (or its dimension parallel to the edge of the panel) generally be made not less than one-fifth of the dimension of the panel from center to center of adjacent columns. A diameter equal to 0.225 of the panel length has been used quite widely and acceptably. For heavy loads or large panels especial attention should be given to designing and reinforcing the column capital with respect to compressive stresses and bending moments. In the case of heavy loads or large panels, and where the conditions of the panel loading or variations in panel length or other conditions cause high bending stresses in the column, and also for column capitals smaller than the size herein recommended, especial attention should be given to designing and reinforcing

the column capital with respect to compression and to rigidity of connection to floor slab.

(*b*) *Dropped Panel* — In one type of construction the slab is thickened throughout an area surrounding the column capital. The square or oblong of thickened slab thus formed is called a dropped panel or a drop. The thickness and the width of the dropped panel may be governed by the amount of resisting moment to be provided (the compressive stress in the concrete being dependent upon both thickness and width), or its thickness may be governed by the resistance to shear required at the edge of the column capital and its width by the allowable compressive stresses and shearing stresses in the thinner portion of the slab adjacent to the dropped panel. Generally, however, it is recommended that the width of the dropped panel be at least four-tenths of the corresponding side of the panel as measured from center to center of columns, and that the offset in thickness be not more than five-tenths of the thickness of the slab outside the dropped panel.

(*c*) *Slab Thickness* — In the design of a slab, the resistance to bending and to shearing forces will largely govern the thickness, and, in the case of large panels with light loads, resistance to deflection may be a controlling factor. The following formulas for minimum thicknesses are recommended as general rules of design when the diameter of the column capital is not less than one-fifth of the dimension of the panel from center to center of adjacent columns, the larger dimension being used in the case of oblong panels. For notation, let

t = total thickness of slab in inches.
L = panel length in feet.
w = sum of live load and dead load in pounds per square foot.

Then, for a slab without dropped panels, minimum $t = 0.024\ L\sqrt{w} + 1\frac{1}{2}$; for a slab with dropped panels, minimum $t = 0.02\ L\sqrt{w} + 1$; for a dropped panel whose width is four-tenths of the panel length, minimum $t = 0.03\ L\sqrt{w} + 1\frac{1}{2}$.

In no case should the slab thickness be made less than six inches, nor should the thickness of a floor slab be made less

than one-thirty-second of the panel length, nor the thickness of a roof slab less than one-fortieth of the panel length.

(*d*) *Bending and Resisting Moments in Slabs* — If a vertical section of a slab be taken across a panel along a line midway between columns, and if another section be taken along an edge

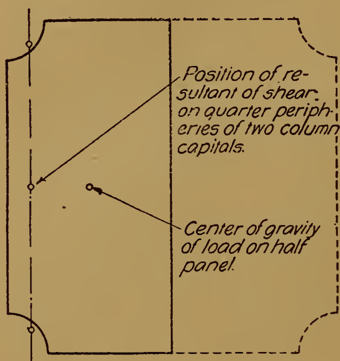


FIG. 1.

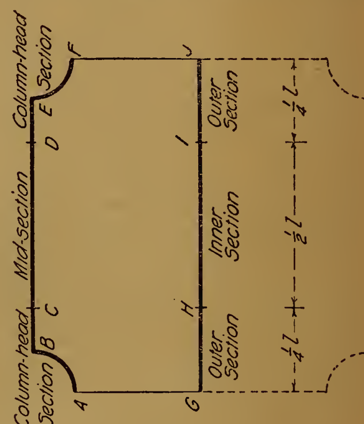


FIG. 2.

of the panel parallel to the first section, but skirting the part of the periphery of the column capitals at the two corners of the panels, the moment of the couple formed by the external load on the half panel, exclusive of that over the column capital (sum of dead and live load) and the resultant of the external shear or reaction at the support at the two column capitals (see Fig. 1), may be found by ordinary static analysis. It will be noted that the edges of the area here considered are along lines of zero shear except around the column capitals. This moment of the external forces acting on the half panel will be resisted by the numerical sum of (*a*) the moment of the internal stresses at the section of the panel midway between columns (positive resisting moment) and (*b*) the moment of the internal stresses at the section referred to at the end of the panel (negative resisting moment). In the curved portion of the end section (that skirting the column), the stresses considered are the components which act parallel to the normal stresses on the straight

portion of the section. Analysis shows that, for a uniformly distributed load, and round columns, and square panels, the numerical sum of the positive moment and the negative moment at the two sections named is given quite closely by the equation.

$$M_x = \frac{1}{8} wl\ (l - \frac{2}{3}c)^2.$$

In this formula and in those which follow relating to oblong panels,

w = sum of the live and dead load per unit of area;

l = side of a square panel measured from center to center of columns;

l_1 = one side of the oblong panel measured from center to center of columns;

l_2 = other side of oblong panel measured in the same way;

c = diameter of the column capital;

M_x = numerical sum of positive moment and negative moment in one direction.

M_y = numerical sum of positive moment and negative moment in the other direction.

(See paper and closure, Statical Limitations upon the Steel Requirement in Reinforced Concrete Flat Slab Floors, by John R. Nichols, Jun. Am. Soc. C. E., Transactions Am. Soc. C. E., Vol. LXXVII.)

For oblong panels, the equations for the numerical sums of the positive moment and the negative moment at the two sections named become,

$$M_x = \frac{1}{8} wl_2\ (l_1 - \frac{2}{3}c)^2$$

$$M_y = \frac{1}{8} wl_1\ (l_2 - \frac{2}{3}c)^2$$

where M_x is the numerical sum of the positive moment and the negative moment for the sections parallel to the dimension l_2, and M_y is the numerical sum of the positive moment and the negative moment for the sections parallel to the dimension l_1.

What proportion of the total resistance exists as positive moment and what as negative moment is not readily determined. The amount of the positive moment and that of the negative moment may be expected to vary somewhat with the design of

the slab. It seems proper, however, to make the division of total resisting moment in the ratio of three-eighths for the positive moment to five-eighths for the negative moment.

With reference to variations in stress along the sections, it is evident from conditions of flexure that the resisting moment is not distributed uniformly along either the section of positive moment or that of negative moment. As the law of the distribution is not known definitely, it will be necessary to make an empirical apportionment along the sections; and it will be considered sufficiently accurate generally to divide the sections into two parts and to use an average value over each part of the panel section.

The relatively large breadth of structure in a flat slab makes the effect of local variations in the concrete less than would be the case for narrow members like beams. The tensile resistance of the concrete is less affected by cracks. Measurements of deformations in buildings under heavy load indicate the presence of considerable tensile resistance in the concrete, and the presence of this tensile resistance acts to decrease the intensity of the compressive stresses. It is believed that the use of moment coefficients somewhat less than those given in a preceding paragraph as derived by analysis is warranted, the calculations of resisting moment and stresses in concrete and reinforcement being made according to the assumptions specified in this report and no change being made in the values of the working stresses ordinarily used. Accordingly, the values of the moments which are recommended for use are somewhat less than those derived by analysis. The values given may be used when the column capitals are round, oval, square, or oblong.

(*e*) *Names for Moment Sections* — For convenience, that portion of the section across a panel along a line midway between columns which lies within the middle two quarters of the width of the panel (HI, Fig 2) will be called the inner section, and that portion in the two outer quarters of the width of the panel (GH and IJ, Fig. 2) will be called the outer sections. Of the section which follows a panel edge from column capital

to column capital and which includes the quarter peripheries of the edges of two column capitals, that portion within the middle two quarters of the panel width (CD, Fig. 2) will be called the mid-section, and the two remaining portions (ABC and DEF, Fig. 2), each having a projected width equal to one-fourth of the panel width, will be called the column-head sections.

(*f*) *Positive Moment* — For a square interior panel, it is recommended that the positive moment for a section in the middle of a panel extending across its width be taken as $\frac{1}{25} wl (l - \frac{2}{3} c)^2$. Of this moment, at least 25 per cent should be provided for in the inner section; in the two outer sections of the panel at least 55 per cent of the specified moment should be provided for in slabs not having dropped panels, and at least 60 per cent in slabs having dropped panels, except that in calculations to determine necessary thickness of slab away from the dropped panel at least 70 per cent of the positive moment should be considered as acting in the two outer sections.

(*g*) *Negative Moment* — For a square interior panel, it is recommended that the negative moment for a section which follows a panel edge from column capital to column capital and which includes the quarter peripheries of the edges of the two column capitals (the section altogether forming the projected width of the panel) be taken as $\frac{1}{15} wl (l - \frac{2}{3} c)^2$. Of this negative moment, at least 20 per cent should be provided for in the mid-section and at least 65 per cent in the two column-head sections of the panel, except that in slabs having dropped panels at least 80 per cent of the specified negative moment should be provided for in the two column-head sections of the panel.

(*h*) *Moments for Oblong Panels* — When the length of a panel does not exceed the breadth by more than 5 per cent, computation may be made on the basis of a square panel with sides equal to the mean of the length and the breadth.

When the long side of an interior oblong panel exceeds the short side by more than one-twentieth and by not more than

one-third of the short side, it is recommended that the positive moment be taken as $\frac{1}{25} wl_2 \ (l_1 - \frac{2}{3} c)^2$ on a section parallel to the dimension l_2, and $\frac{1}{25} wl_1 \ (l_2 - \frac{2}{3} c)^2$ on a section parallel to the dimension l_1; and that the negative moment be taken as $\frac{1}{15} wl_2 \ (l_1 - \frac{2}{3} c)^2$ on a section at the edge of the panel corresponding to the dimension l_2, and $\frac{1}{15} wl_1 \ (l_2 - \frac{2}{3} c)^2$ at a section in the other direction. The limitations of the apportionment of moment between inner section and outer section and between mid-section and column-head sections may be the same as for square panels.

(*i*) *Wall Panels* — The coefficient of negative moment at the first row of columns away from the wall should be increased 20 per cent over that required for interior panels, and likewise the coefficient of positive moment at the section half way to the wall should be increased by 20 per cent. If girders are not provided along the wall or the slab does not project as a cantilever beyond the column line, the reinforcement parallel to the wall for the negative moment in the column-head section and for the positive moment in the outer section should be increased by 20 per cent. If the wall is carried by the slab this concentrated load should be provided for in the design of the slab. The coefficient of negative moments at the wall to take bending in the direction perpendicular to the wall line may be determined by the conditions of restraint and fixedness as found from the relative stiffness of columns and slab, but in no case should it be taken as less than one-half of that for interior panels.

(*j*) *Reinforcement* — In the calculation of moments all the reinforcing bars which cross the section under consideration and which fulfill the requirements given under paragraph (*l*) of this chapter may be used. For a column-head section reinforcing bars parallel to the straight portion of the section do not contribute to the negative resisting moment for the column-head section in question. In the case of four-way reinforcement

the sectional area of the diagonal bars multiplied by the sine of the angle between the diagonal of the panel and the straight portion of the section under consideration may be taken to act as reinforcement in a rectangular direction.

(*k*) *Point of Inflection* — For the purpose of making calculations of moments at sections away from the sections of negative moment and positive moment already specified, the point of inflection on any line parallel to a panel edge may be taken as one-fifth of the clear distance on that line between the two sections of negative moment at the opposite ends of the panel indicated in Paragraph (*e*), of this chapter. For slabs having dropped panels the coefficient of one-fourth should be used instead of one-fifth.

(*l*) *Arrangement of Reinforcement* — The design should include adequate provision for securing the reinforcement in place so as to take not only the maximum moments but the moments at intermediate sections. All bars in rectangular bands or diagonal bands should extend on each side of a section of maximum moment, either positive or negative, to points at least twenty diameters beyond the point of inflection as defined herein or be hooked or anchored at the point of inflection. In addition to this provision bars in diagonal bands used as reinforcement for negative moment should extend on each side of a line drawn through the column center at right angles to the direction of the band at least a distance equal to thirty-five one-hundredths of the panel length, and bars in diagonal bands used as reinforcement for positive moment should extend on each side of a diagonal through the center of the panel at least a distance equal to thirty-five one-hundredths of the panel length; and no splice by lapping should be permitted at or near regions of maximum stress except as just described. Continuity of reinforcing bars is considered to have advantages, and it is recommended that not more than one-third of the reinforcing bars in any direction be made of a length less than the distance center to center of columns in that direction. Continuous bars should not all be bent up at the same point of their length, but the zone in which this bending occurs should extend on each

side of the assumed point of inflection, and should cover a width of at least one-fifteenth of the panel length. Mere draping of the bars should not be permitted. In four-way reinforcement the position of the bars in both diagonal and rectangular directions may be considered in determining whether the width of zone of bending is sufficient.

(*m*) *Reinforcement at Construction Joints* — It is recommended that at construction joints extra reinforcing bars equal in section to 20 per cent of the amount necessary to meet the requirements for moments at the section where the joint is made be added to the reinforcement, these bars to extend not less than 50 diameters beyond the joint on each side.

(*n*) *Tensile and Compressive Stresses* — The usual method of calculating the tensile and compressive stresses in the concrete and in the reinforcement, based on the assumptions for internal stresses given in this chapter, should be followed. In the case of the dropped panel the section of the slab and dropped panel may be considered to act integrally for a width equal to the width of the column-head section.

(*o*) *Provision for Diagonal Tension and Shear* — In calculations for the shearing stress which is to be used as the means of measuring the resistance to diagonal tension stress, it is recommended that the total vertical shear on two column-head sections constituting a width equal to one-half the lateral dimension of the panel, for use in the formula for determining critical shearing stresses, be considered to be one-fourth of the total dead and live load on a panel for a slab of uniform thickness, and to be three-tenths of the sum of the dead and live loads on a panel for a slab with dropped panels. The formula for shearing unit stress given in Chapter X of this report may then be written $v = \frac{0.25W}{bjd}$ for slabs of uniform thickness, and $v = \frac{0.30W}{bjd}$ for slabs with dropped panels, where W is the sum of the dead and live load on a panel, b is half the lateral dimension of the panel measured from center to center of columns, and jd is the lever arm of the resisting couple at the section.

The calculation of what is commonly called punching shear may be made on the assumption of a uniform distribution over the section of the slab around the periphery of the column capital and also of a uniform distribution over the section of the slab around the periphery of the dropped panel, using in each case an amount of vertical shear greater by 25 per cent than the total vertical shear on the section under consideration.

The values of working stresses should be those recommended for diagonal tension and shear in Chapter VIII.

(*p*) *Walls and Openings* — Girders or beams should be constructed to carry walls and other concentrated loads which are in excess of the working capacity of the slab. Beams should also be provided in case openings in the floor reduce the working strength of the slab below the required carrying capacity.

(*q*) *Unusual Panels* — The coefficients, apportionments, and thicknesses recommended are for slabs which have several rows of panels in each direction, and in which the size of the panels is approximately the same. For structures having a width of one, two, or three panels, and also for slabs having panels of markedly different sizes, an analysis should be made of the moments developed in both slab and columns, and the values given herein modified accordingly. Slabs with paneled ceiling or with depressed paneling in the floor are to be considered as coming under the recommendations herein given.

(*r*) *Bending Moments in Columns* — Provision should be made in both wall columns and interior columns for the bending moment which will be developed by unequally loaded panels, eccentric loading, or uneven spacing of columns. The amount of moment to be taken by a column will depend upon the relative stiffness of columns and slab, and computations may be made by rational methods, such as the principle of least work, or of slope and deflection. Generally, the larger part of the unequalized negative moment will be transmitted to the columns, and the column should be designed to resist this bending moment. Especial attention should be given to wall columns and corner columns.

Chapter VIII

Working Stresses

General Assumptions

The following working stresses are recommended for static loads. Proper allowances for vibration and impact are to be added to live loads where necessary to produce an equivalent static load before applying the unit stresses in proportioning parts.

In selecting the permissible working stress on concrete, the designer should be guided by the working stresses usually allowed for other materials of construction, so that all structures of the same class composed of different materials may have approximately the same degree of safety.

The following recommendations as to allowable stresses are given in the form of percentages of the ultimate strength of the particular concrete which is to be used; this ultimate strength is that developed at an age of 28 days, in cylinders 8 inches in diameter and 16 inches long, of the consistency described in Chapter IV, made and stored under laboratory conditions. In the absence of definite knowledge in advance of construction as to just what strength may be expected, the Committee submits the following values as those which should be obtained with materials and workmanship in accordance with the recommendations of this report.

Although occasional tests may show higher results than those here given, the Committee recommends that these values should be the maximum used in design.

Table of Compressive Strengths of Different Mixtures of Concrete

(In Pounds per Square Inch)

Aggregate	1 : 3*	1 : 4½*	1 : 6*	1 : 7½*	1 : 9*
Granite, trap rock	3300	2800	2200	1800	1400
Gravel, hard limestone and hard sandstone	3000	2500	2000	1600	1300
Soft limestone and sandstone	2200	1800	1500	1200	1000
Cinders	800	700	600	500	400

Note.—For variations in the moduli of elasticity see Chapter VIII,

* Combined volume fine and coarse aggregates measured separately.

Bearing

When compression is applied to a surface of concrete of at least twice the loaded area, a stress of 35 per cent of the compressive strength may be allowed in the area actually under load.

Axial Compression

For concentric compression on a plain concrete pier, the length of which does not exceed 4 diameters, or on a column reinforced with longitudinal bars only, the length of which does not exceed 12 diameters, 22.5 per cent of the compressive strength may be allowed.

For other forms of columns the stresses obtained from the ratios given in Chapter VII may govern.

Compression in Extreme Fiber

The extreme fiber stress of a beam, calculated on the assumption of a constant modulus of elasticity for concrete under working stresses may be allowed to reach 32.5 per cent of the compressive strength. Adjacent to the support of continuous beams stresses 15 per cent higher may be used.

Shear and Diagonal Tension

In calculations on beams in which the maximum shearing stress in a section is used as the means of measuring the resistance to diagonal tension stress, the following allowable values for the maximum vertical shearing stress in concrete, calculated by the method given in Chapter X, Formula 22, are recommended:

(*a*) For beams with horizontal bars only and without web reinforcement, 2 per cent of the compressive strength.

(*b*) For beams with web reinforcement consisting of vertical stirrups looped about the longitudinal reinforcing bars in the tension side of the beam and spaced horizontally not more than one-half the depth of the beam; or for beams in which longitudinal bars are bent up at an angle of not more than 45 degrees or less than 20 degrees with the axis of the beam, and the points of bending are spaced horizontally not more than three-quarters of the depth of the beam apart, not to exceed 4½ per cent of the compressive strength.

(*c*) For a combination of bent bars and vertical stirrups looped about the reinforcing bars in the tension side of the beam and spaced horizontally not more than one-half of the depth of the beam, 5 per cent of the compressive strength.

(*d*) For beams with web reinforcement (either vertical or inclined) securely attached to the longitudinal bars in the tension side of the beam in such a way as to prevent slipping of bar past the stirrup, and spaced horizontally not more than one-half of the depth of the beam in case of vertical stirrups and not more than three-fourths of the depth of the beam in the case of inclined members, either with longitudinal bars bent up or not, 6 per cent of the compressive strength.

The web reinforcement in case any is used should be proportioned by using two-thirds of the external vertical shear in Formula 24 or 25 in Chapter X. The effect of longitudinal bars bent up at an angle of from 20 to 45 degrees with the axis of the beam may be taken at sections of the beam in which the bent up bars contribute to diagonal tension resistance as defined under Chapter VII, as reducing the shearing stresses to be otherwise provided for. The amount of reduction of the shearing stress by means of bent up bars will depend upon their capacity, but in no case should be taken as greater than 4½ per cent of the compressive strength of the concrete over the effective cross-section of the beam (Formula 22). The limit of tensile stress in the bent up portion of the bar calculated by Formula 25, using in this formula an amount of total shear corresponding to the reduction in shearing stress assumed for the bent up bars, may be taken as specified for the working stress of steel, but in the calculations the stress in the bar due to its part as longitudinal reinforcement of the beam should be considered. The stresses in stirrups and inclined members when combined with bent up bars are to be determined by finding the amount of the total shear which may be allowed by reason of the bent up bars, and subtracting this shear from the total external vertical shear. Two-thirds of the remainder will be the shear to be carried by the stirrups, using Formulas 24 or 25 in Chapter X.

Where punching shears occur, provided the diagonal tension requirements are met, a shearing stress of 6 per cent of the compressive strength may be allowed.

Bond

The bond stress between concrete and plain reinforcing bars may be assumed at 4 per cent of the compressive strength, or 2 per cent in the case of drawn wire. In the best types of deformed bar the bond stress may be increased, but not to exceed 5 per cent of the compressive strength of the concrete.

Reinforcement

The tensile or compressive stress in steel should not exceed 16,000 lbs. per sq. in.

In structural steel members the working stresses adopted by the American Railway Engineering Association are recommended.

Modulus of Elasticity

The value of the modulus of elasticity of concrete has a wide range, depending on the materials used, the age, the range of stresses between which it is considered, as well as other conditions. It is recommended that in computations for the position of the neutral axis, and for the resisting moment of beams and for compression of concrete in columns, it be assumed as:

(*a*) One-fortieth that of steel, when the strength of the concrete is taken as not more than 800 lb. per sq. in.

(*b*) One-fifteenth that of steel, when the strength of the concrete is taken as greater than 800 lb. per sq. in. and less than 2200 lb. per sq. in.

(*c*) One-twelfth that of steel, when the strength of the concrete is taken as greater than 2200 lb. per sq. in. and less than 2900 lb. per sq. in., and

(*d*) One-tenth that of steel, when the strength of the concrete is taken as greater than 2900 lb. per sq. in.

Although not rigorously accurate, these assumptions will give safe results. For the deflection of beams which are free to move longitudinally at the supports, in using formulas for deflection which do not take into account the tensile strength developed in the concrete, a modulus of one-eighth of that of steel is recommended.

Chapter IX

Conclusion

In the preparation of this Final Report, 21 members have taken a more or less active part; all members have agreed to it in its present form.

The Joint Committee acknowledges its indebtedness to its sub-committee on design, Professors Talbot, Hatt and Turneaure, for their invaluable and devoted service.

The Joint Committee believes that there is a great advantage in the co-operation of the representatives of different technical societies, and trusts that a similar combination of effort may be possible, some time in the future, to review the work done by the present Committee, and to embody the additional knowledge which will certainly be obtained from further experimentation and practical experience with this important material of construction.

Respectfully submitted,

JOSEPH R. WORCESTER, *Chairman.*
EMIL SWENSSON, *Vice-Chairman.*
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SPENCER B. NEWBERRY,
EDWARD GODFREY,[1]
EGBERT J. MOORE,
LEONARD C. WASON.

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[1]Mr. Godfrey dissents from the Report in the whole matter of stirrups and their treatment. He would give stirrups and short shear members no recognition, for the reason that he holds that they have not shown themselves to have any definite value in tests and that analysis fails to show that any definite value can be ascribed to them; he also believes

Chapter X

Appendix

Suggested Formulas for Reinforced Concrete Construction

These formulas are based on the assumptions and principles given in the chapter on design.

Standard Notation

(a) *Rectangular Beams.*

The following notation is recommended:

f_s = tensile unit stress in steel;

f_c = compressive unit stress in concrete;

E_s = modulus of elasticity of steel;

E_c = modulus of elasticity of concrete;

$n = \frac{E_s}{E_c}$;

M = moment of resistance, or bending moment in general;

---

that dependence on stirrups to take end shear has resulted in much unsafe construction and some failures. He would take care of diagonal tension by bending up some of the main reinforcing rods and anchoring them for their full tensile strength beyond the edge of support. He recommends that bends be made close to the supports for the upper bends and at quarter points for the lower bends in beams carrying uniform load. For girders carrying beams bends should be made under the beams. For anchorage he recommends that the rod should extend 40 to 50 diameters beyond the point where it intersects a line drawn, at 45 degrees with the horizontal from the bottom of the beam at the face of the support.

He recommends that the stress in bent-up rods be assumed to be that obtained by multiplying the excess of shear over that taken by the concrete (at 40 or 50 lb per sq. in.) by the secant of the inclination of the rod with the vertical.

Mr. Godfrey also dissents from all parts of the Report relating to rodded columns, or columns having longitudinal rods without close-spaced hooping, for the reason that he holds that such reinforcement has not shown itself to have any definite value in tests on columns, and that analysis fails to show that any definite value can be ascribed to it, when such analysis takes into account the necessity for toughness in all columns; he also believes that dependence on such reinforcement has led to much unsafe construction and many failures. He would recognize as reinforced concrete columns only such columns as have in addition to the longitudinal rods a complete system of close-spaced hooping He objects to the reading of Chapter VII, as being capable of interpretation that hooped columns are given an advantage in the matter of unit stresses only below ten diameters in height. He recommends the standardization of hooped columns and suggests that columns be reinforced by a coil or hoops of round steel having a diameter one-fortieth of that of the external diameter of the column and eight upright rods wired to the same, the pitch of the coil being one-eighth of the column diameter. He would consider available for resisting compressive stress, the entire area of the concrete of a circular column or of an octagonal column, but no part of the longitudinal rods or hooping. In a square column only 83 per cent of the area of concrete would be considered available. The compression he would recommend on columns (for 2000-lb. concrete) would be:

$$P = 670 - 12\ l/d.$$

where P = allowable compression in pounds per square inch.
l = length of column in inches.
d = diameter of column in inches.

A_s = steel area;
b = breadth of beam;
d = depth of beam to center of steel;
k = ratio of depth of neutral axis to depth, d;
z = depth below top to resultant of the compressive stresses;
j = ratio of lever arm of resisting couple to depth, d;
jd = $d - z$ = arm of resisting couple;
p = steel ratio $= \frac{A_s}{bd}$.

(*b*) *T-Beams.*

b = width of flange;
b' = width of stem;
t = thickness of flange.

(*c*) *Beams Reinforced for Compression.*

A' = area of compressive steel;
p' = steel ratio for compressive steel;
f'_s = compressive unit stress in steel;
C = total compressive stress in concrete;
C' = total compressive stress in steel;
d' = depth to center of compressive steel;
z = depth to resultant of C and C'.

(*d*) *Shear, Bond and Web Reinforcement.*

V = total shear;
V' = total shear producing stress in reinforcement;
v = shearing unit stress;
u = bond stress per unit area of bar;
o = circumference or perimeter of bar;
Σo = sum of the perimeters of all bars;
T = total stress in single reinforcing member;
s = horizontal spacing of reinforcing members.

(*e*) *Columns.*

A = total net area;
A_s = area of longitudinal steel;
A_c = area of concrete;
P = total safe load.

Formulas

(*a*) *Rectangular Beams.*

Position of neutral axis,

$$k=\sqrt{2pn+(pn)^2}-pn \quad\quad (1)$$

Arm of resisting couple,

$$j=1-\frac{1}{3}k \quad\quad (2)$$

[For f_s = 15000 to 16000 and f_c = 600 to 650, j may be taken at $\frac{7}{8}$.]

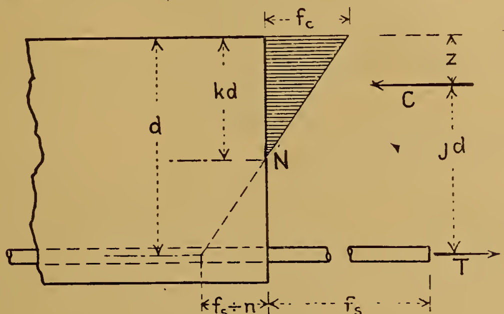


FIG. 1.

Fiber stresses,

$$f_s=\frac{M}{A_s jd}=\frac{M}{pjbd^2} \quad\quad (3)$$

$$f_c=\frac{2M}{jkbd^2}=\frac{2pf_s}{k} \quad\quad (4)$$

Steel ratio, for balanced reinforcement,

$$p=\tfrac{1}{2}\cdot\frac{1}{\frac{f_s}{f_c}\left(\frac{f_s}{nf_c}+1\right)} \quad\quad (5)$$

(*b*) *T-Beams.*

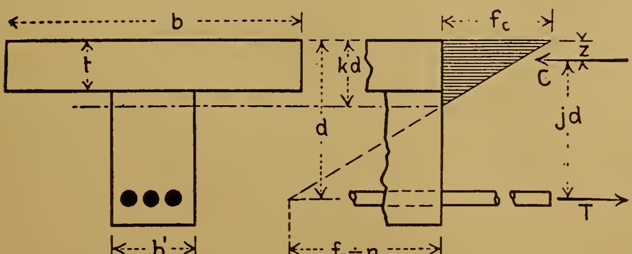


FIG. 2.

Case I. When the neutral axis lies in the flange, use the formulas for rectangular beams.

Case II. When the neutral axis lies in the stem.

The following formulas neglect the compression in the stem.

Position of neutral axis,

$$kd=\frac{2ndA_s+bt_2}{2nA_s+2bt} \quad \text{(6)}$$

Position of resultant compression,

$$z=\frac{3kd-2t}{2kd-t}\cdot\frac{t}{3} \quad \text{(7)}$$

Arm of resisting couple,

$$jd=d-z \quad \text{(8)}$$

Fiber stresses,

$$f_s=\frac{M}{A_s jd} \quad \text{(9)}$$

$$f_c=\frac{Mkd}{bt(kd-\frac{1}{2}t)jd}=\frac{f_s}{n}\cdot\frac{k}{1-k} \quad \text{(10)}$$

(For approximate results the formulas for rectangular beams may be used.)

The following formulas take into account the compression in the stem; they are recommended where the flange is small compared with the stem:

Position of neutral axis,

$$kd=\sqrt{\frac{2ndA_s+(b-b')t^2}{b'}+\left(\frac{nA_s+(b-b')t}{b'}\right)^2}-\frac{nA_s+(b-b')t}{b'} \quad \text{(11)}$$

Position of resultant compression,

$$z=\frac{(kdt^2-\frac{2}{3}t^3)b+[(kd-t)^2(t+\frac{1}{3}(kd-t))]b'}{t(2kd-t)b+(kd-t)^2b'} \quad \text{(12)}$$

Arm of resisting couple,

$$jd=d-z \quad \text{(13)}$$

Fiber stresses,

$$f_s=\frac{M}{A_s jd} \quad \text{(14)}$$

$$f_c=\frac{2Mkd}{[(2kd-t)bt+(kd-t)^2b']jd} \quad \text{(15)}$$

(*c*) *Beams Reinforced for Compression.*

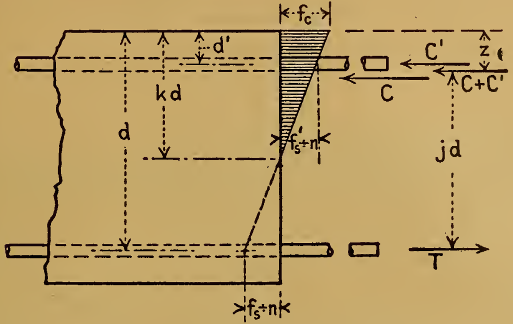


FIG. 3.

Position of neutral axis,

$$k=\sqrt{2n\left(p+p'\frac{d'}{d}\right)+n^2(p+p')^2}-n(p+p') \quad \dots\dots\dots\dots (16)$$

Position of resultant compression,

$$z=\frac{\frac{1}{3}k^3d+2p'nd'\left(k-\frac{d'}{d}\right)}{k^2+2p'n\left(k-\frac{d'}{d}\right)} \quad \dots\dots\dots\dots (17)$$

Arm of resisting couple,

$$jd=d-z \dots\dots\dots\dots (18)$$

Fiber stresses,

$$f_c=\frac{6M}{bd^2\left[3k-k^2+\frac{6p'n}{k}\left(k-\frac{d'}{d}\right)\left(1-\frac{d'}{d}\right)\right]} \quad \dots\dots (19)$$

$$f_s=\frac{M}{pjbd^2}=nf_c\frac{1-k}{k} \quad \dots\dots\dots\dots (20)$$

$$f_s'=nf_c\frac{k-\frac{d'}{d}}{k} \quad \dots\dots\dots\dots (21)$$

(*d*) *Shear, Bond, and Web Reinforcement.*

For rectangular beams,

$$v=\frac{V}{bjd} \quad \dots\dots\dots\dots (22)$$

$$u=\frac{V}{jd\,.\,\Sigma o} \quad \dots\dots\dots\dots (23)$$

[For approximate results j may be taken at $\frac{7}{8}$.]

The stresses in web reinforcement may be estimated by means of the following formulas:

Vertical web reinforcement,

$$T = \frac{V's}{jd} \quad \text{(24)}$$

Bars bent up at angles between 20 and 45 degrees with the horizontal and web members inclined at 45 degrees,

$$T = \frac{3}{4}\frac{V's}{jd} \quad \text{(25)}$$

In the text of the report it is recommended that two-thirds of the external vertical shear (total shear) at any section be taken as the amount of total shear producing stress in the web reinforcement. V' therefore equals two-thirds of V.

The same formulas apply to beams reinforced for compression as regards shear and bond stress for tensile steel.

For T-Beams,

$$v = \frac{V}{b'jd} \quad \text{(26)}$$

$$u = \frac{V}{jd \,.\, \Sigma o} \quad \text{(27)}$$

[For approximate results j may be taken at 7/8.]

(*e*) *Columns.*

Total safe load,

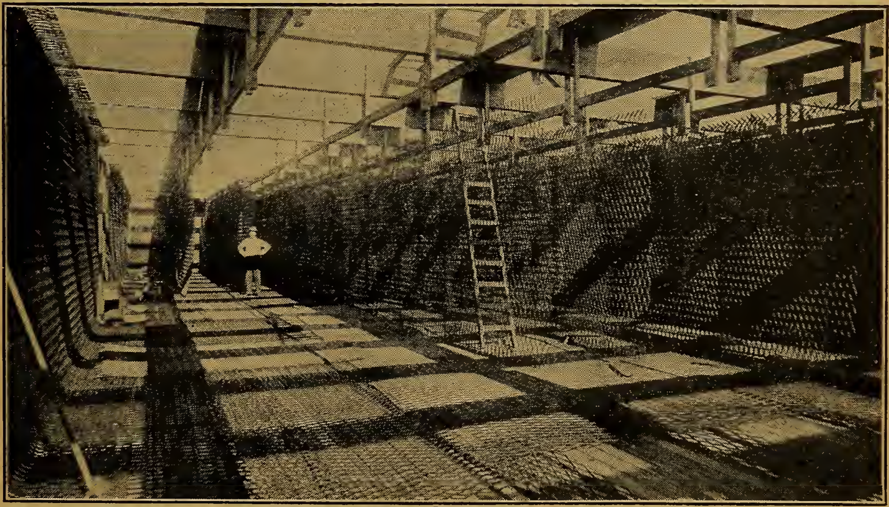
$$P = f_c(A_c + nA_s) = f_c A(1 + (n-1)p) \quad \text{(28)}$$

Unit stresses,

$$f_c = \frac{P}{A(1 + (n-1)p)} \quad \text{(29)}$$

$$f_s = nf_c \quad \text{(30)}$$

End of Joint Committee Report



The adaptability of "Steelcrete" Mesh is unlimited. In 1913 and 1914 two concrete barges were constructed in Baltimore harbor of 600 ton capacity, 31 ft. x 113 ft., "Steelcrete" mesh reinforcement used throughout

"Steelcrete" Mesh in Floor Construction

THE methods or systems of using "Steelcrete" Mesh as a reinforcement in floors are innumerable. The following have been selected because of their popularity, and are typical of the methods employed in the structures for which they are suggested. Variations may be adapted to suit special cases by engineers or architects.

Systems No. 1B, 3A, and 2A may be used with or without the suspended ceiling as shown in System No. 1A. This method is used wherever a level ceiling is desirable. The confined air space serves to deaden the sound. It is adapted to office buildings, loft buildings, hotels, hospitals, schools, apartment houses, residences, etc. The open panel construction is adapted to warehouses, retail stores, office buildings, hotels, etc., where the panelled finish is desired or permissible.

The floors may be of any form indicated by the character of the building.

The attention of the architects is called to the "Steelcrete" beam wrapper which is required around the lower flanges of beams when concrete protection is deemed necessary. This will be found fully described elsewhere.

The tables of safe superimposed live loads will supply all the data necessary for the design of a floor system.

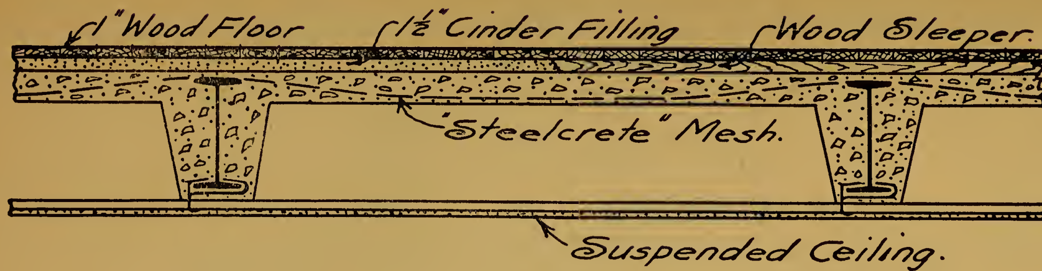


Fig. (4)—System No. 1A

This system is a very popular form of construction. It is adapted for office buildings, hotels, apartment houses, hospitals, schools, roofs, etc. The protection of the lower flange of the supporting beams makes it an ideal fireproof construction. It may be used with or without the suspended ceiling construction as here shown

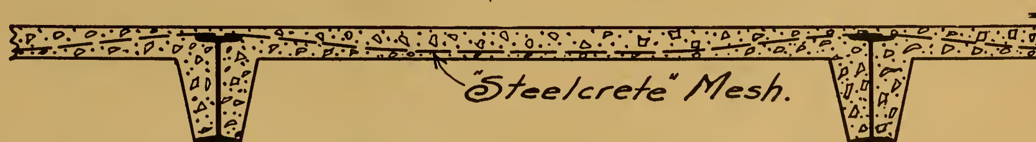


Fig. (5)—System No. 1B

This system is similar to No. 1A. It is adapted for the same class of buildings wherever beam protection is considered unnecessary. The advantages of this system are that it is easily erected in addition to being strong and safe. The open panel construction is here shown

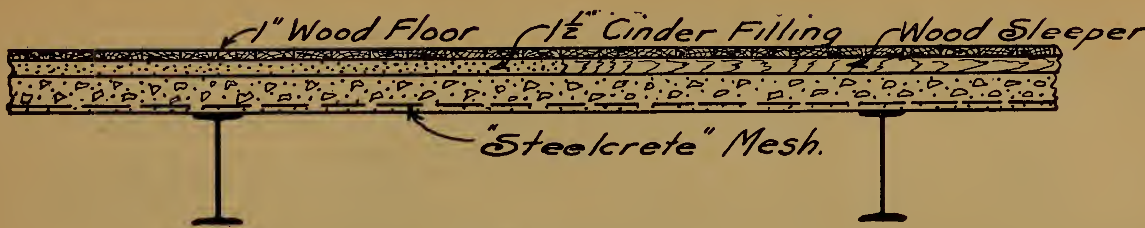


Fig. (6)—System No. 2A

Adapted for structures where beam protection is unnecessary, such as bridge floors, stations, factory floors, purlin roofs, sidewalks, etc. The advantage of this system is the low cost of forms for erection, and the rapidity of installation

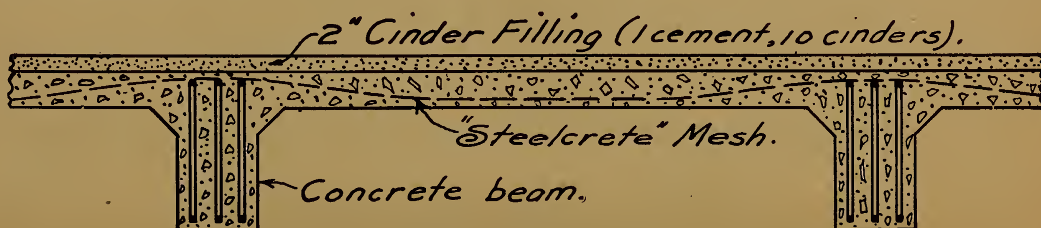


Fig. (7)—System No. 3A

This system is similar to Nos. 1A, 1B, and 1C. It shows "Steelcrete" Mesh adapted to a reinforced concrete structure

Fig. (8)—System No. 4A

This is the strongest form of construction for floor slabs. It is adapted to warehouses, breweries, garages, press floors, etc.

Embody This in Your Specifications

THE slabs shall be reinforced with "Steelcrete" expanded metal of such size as shall carry a superimposed load of_ _ _ _lbs. per sq. ft., developing a maximum strength of 18,500 lbs. per sq. in. on the steel. The thickness of slab shall be determined by the strength of the concrete which should develop a maximum stress of 650 lbs. per sq. in. The bending moment factor shall be $\frac{1}{12}$ W L where the reinforcement is continuous over both supports, ⅛ W L where the reinforcement is not continuous over either support and $\frac{1}{10}$ W L where the reinforcement is continuous over one support and does not extend beyond the other support.

(or —"The slabs shall be reinforced with 'Steelcrete' Expanded Metal, size_ _ _ _ _ _ _ _, as indicated on the drawings.")

"Steelcrete" Expanded Metal
A Standardized Reinforcement

THE standard sizes of "Steelcrete" mesh have been so designed as to be of most service in concrete work. The determining factor of the relative strength of concrete reinforcement is the sectional area or the square inches of steel per foot of width. The scale of sizes of "Steelcrete" Mesh adopted for standard use varies by an arithmetical progression on this basis. The designation of each mesh indicates the sectional area of the steel. The great advantage thus offered is obvious.

The standard size of the diamond in all cases is 3″ x 8″. The different sectional areas are attained by varying either the thickness or the width of the strands. This size mesh has been adopted as a standard after years of experience and much thought. Meshes of smaller diamonds are available but although not applicable to concrete reinforcement, are extensively used for other purposes.

An illustration of the meaning conveyed in the designation of a "Steelcrete" mesh can best be given as follows:—size 3-9-15 is the standard designation of a mesh having a sectional area of .15 sq. in. per foot of width. The thickness of plate is approximately No. 9 (Stubbs) gauge and the width of diamond, 3 inches. Size 3-6-40 indicates a mesh of .40 sq. in. per foot of width, made of approximately No. 6 (Stubbs) gauge and having a 3-inch opening. As stated before, all reinforcing meshes have a 3-inch opening. The designer is not usually concerned with the thickness of plate which is included in the designation for convenience of the manufacturer. The determining feature is the sectional area and the progressive variations will be quickly noted and appreciated from a study of the table of standard sizes.

The length of "Steelcrete" mesh sheets is measured by the direction of the long way of the diamond and the width of the sheet at right angles to it. In ordering or specifying expanded metal, it is customary to give the width first and the length second, i. e., 150 sheets, 3-9-15—7′ x 12′. Here 7 ft. is the dimension measured in the direction of the minimum width of the diamond openings and 12 ft. is the dimension measured along the long way of the diamond.

"Steelcrete" expanded metal is furnished in standard lengths of 8 ft., 10 ft., 12 ft. and 16 ft. These constitute the most convenient sizes for handling

on the field. A multiplicity of lengths involves sorting and confusion about a construction. A minimum of lengths on the other hand helps extensively in the efficient progress of work; 12 ft. or 16 ft. lengths are in most cases found sufficient.

The standard widths of "Steelcrete" mesh sheets are fixed by the width of the strands. Sheets of near sectional areas are of different widths. A purpose served by this feature is to eliminate the possibility of error from misplacement of the different sizes. For example, 3-9-15 and 3-9-175 represent different areas and weights of mesh. The difference between the sectional areas of .15 and .175 is not sufficient to enable a foreman on the field to quickly and unerringly select the proper mesh if the width and length of the sheets were identical. The different widths of 6 ft. and 7 ft. eliminates the chance of error from this source.

In conclusion, it is permissible to point out the great value of 16 ft. length sheets. Until recently, it has not been possible to obtain them in lengths greater than 12 ft. Also, the heavy sectional areas serve a field never before attainable in expanded metal.

Standards for "Steelcrete" Expanded Metal Concrete Reinforcement

Designation of Meshes	Sectional Area Sq. in. per ft. of Width	Approximate Weight per Sq. ft. in Pounds	Standard Widths of Sheets	Number of Sheets in a Standard Bundle
3-13-075	.075	.27	6′ 0″	10
3-13-10	.10	.37	6′ 9″	7
3-13-125	.125	.46	5′ 3″	7
3- 9-15	.15	.55	7′ 0″	5
3- 9-175	.175	.64	6′ 0″	5
3- 9-20	.20	.73	5′ 3″	5
3- 9-25	.25	.92	4′ 0″	5
3- 9-30	.30	1.10	7′ 0″	2
3- 9-35	.35	1.28	6′ 0″	2
3- 6-40	.40	1.46	7′ 0″	2
3- 6-45	.45	1.65	6′ 3″	2
3- 6-50	.50	1.83	5′ 9″	2
3- 6-55	.55	2.01	5′ 3″	2
3- 6-60	.60	2.19	4′ 9″	2
3- 1-75	.75	2.74	5′ 9″	1
3- 1-100	1.00	3.63	4′ 3″	1

All sizes are furnished in a standard diamond 3″ x 8″.

All sizes are furnished in stock lengths of 8′, 12′, and 16′. In addition all sizes from 3-13-075 to 3-9-35 inclusive, are furnished in stock lengths of 10′.

3-1-75 and 3-1-100 manufactured to order only.

Introduction to Slab Tables

THERE are two sets of tables hereinafter given, both applicable to stone or gravel concrete. One set of tables is based on an allowable unit stress of 18,500 lbs. per sq. in. on the steel and 750 lbs. per sq. in. on the concrete; another set of tables is based on 16,000 lbs. and 650 lbs. per sq. in. respectively. A stress in the steel of 18,500 lbs. per sq. in. in the case of "Steelcrete" mesh is permissible, representing as it does ⅓ the ultimate value of the elastic limit. The concrete should not be less than a 1:2:5 mixture. So many cities in the United States have building laws requiring smaller values of stresses in the steel and the concrete that the second set of tables were prepared and inserted.

Cinder concrete tables are also included. In very few sections of the United States is anthracite cinder concrete available. Inasmuch as these tables were prepared for use throughout the entire concrete world, cinder concrete tables are properly included. Bituminous cinder concrete has practically been discarded.

The loads given in the tables are the safe live loads in lbs. per sq. ft. In every case the weight of the slab has been deducted. The weights of slab assumed are as follows:—

Slab Thickness		3″	4″	5″	6″	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″	
Weight of Slab	Stone:	37	50	62	75	87	100	112	125	137	150	162	175	187	200	lbs.
	Cinder:	29	38	48	58	67	77	86	96	105	115	125	134	144	153	lbs.

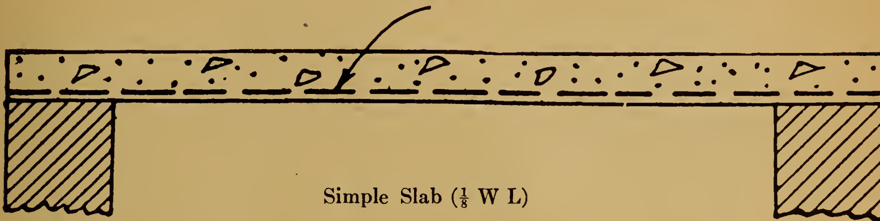
The depth from the bottom of the slab to the center of the steel is assumed as —

For 3-13-075 to 3-6-50 inclusive, ¾″
For 3- 6-55 and 3-6-60 1″
For 3- 1-75 and 3-1-100 1¼″

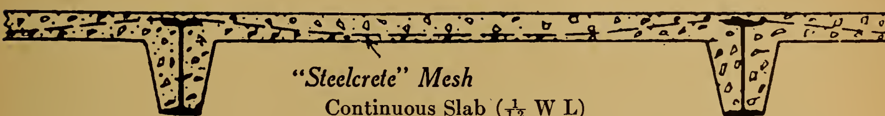
All tables are computed on a basis of $\frac{1}{12}$ W L, this being a factor governed by the style of construction. Other common factors are $\frac{1}{10}$ W L and ⅛ W L. A designer should familiarize himself with these meanings. In general it is recommended that a value of ⅛ W L should be used for a simple slab, a value of $\frac{1}{12}$ W L should be used for a continuous slab and a value of $\frac{1}{10}$ W L should be used for a slab simple on one end and continuous on the other. In the values above given the letter W represents the total live and dead load, and the letter L represents the span in feet.

For the benefit of those not generally familiar with these terms, the following figures will illustrate what is meant by simple, continuous and partially continuous slabs:

"*Steelcrete*" *Mesh*

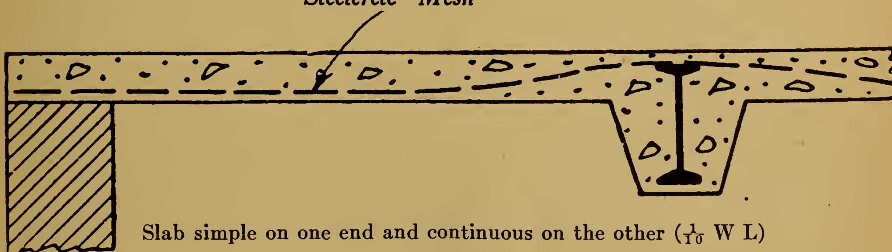


Simple Slab ($\frac{1}{8}$ W L)



"*Steelcrete*" *Mesh*
Continuous Slab ($\frac{1}{12}$ W L)

"*Steelcrete*" *Mesh*



Slab simple on one end and continuous on the other ($\frac{1}{10}$ W L)

Too much emphasis cannot be laid on the fact that the enclosed tables are figured on a bending moment of $\frac{1}{12}$ W L and that these loads are *excessive* in the case of the other styles of construction represented by the factors $\frac{1}{10}$ W L and $\frac{1}{8}$ W L. To obtain the safe live load, it is necessary to *reduce* the amount given in the tables by $\frac{10}{12}$ or $\frac{8}{12}$ as the case may be, after adding to the live load the weight of the slab.

For example: Find the safe live load which a 4-inch slab, reinforced with 3-13-10 "Steelcrete" Expanded Metal, will carry on a simple span of 6 feet, with the unit stress in the concrete and steel 650 and 16000 lbs. per sq. in., respectively.

Looking in the table, we find for the above conditions with a bending moment of $\frac{WL}{12}$, the safe live load is 84 lbs. per sq. ft. Adding the weight of a 4-inch slab, 50 lbs., gives a safe total load of 134 lbs. Then, $\frac{8}{12}$ of 134 lbs. gives 89 lbs. safe total load, and by deducting the weight of the slab, gives a safe live load of 39 lbs. per sq. ft.

"Steelcrete" MESH SLAB TABLES

for use with

GRAVEL OR STONE CONCRETE

Maximum Stress in Steel=18,500 lbs. per sq. inch. Maximum Stress in Concrete=750 lbs. per sq. inch

Maximum Bending Moment=M=$\frac{1}{12}$wl².
where
w=total load per sq. ft. l=center to center span

3-13-075 "Steelcrete" Expanded Metal. Area = 0.075 sq. in. per ft. of width.

Slab	Span.									Unit Stresses lbs. per sq. in.	
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	Concrete	Steel
3"	143	105	78	58	43	31	22				455	18,500
3½	178	131	98	73	55	40	29	19			405	"
4	214	158	119	89	67	50	36	25			370	"
4½	250	185	140	106	80	60	44	31	20		340	"
5	286	213	161	122	93	70	52	37	25		325	"
6	357	266	201	153	117	89	66	48	33		290	"
7	429	321	243	186	142	109	82	60	42	15	260	"
8	500	374	284	218	167	127	96	71	50	19	240	"
9	574	430	327	251	193	148	112	83	60	24	220	"
10	646	484	369	283	218	167	127	94	68	27	210	"
11	719	539	411	316	244	187	143	107	77	32	200	"
12"	792	594	453	348	269	207	158	118	85	36	190	"

3-13-10 "Steelcrete" Expanded Metal. Area = 0.100 sq. in. per ft. of width.

Slab	Span.										Unit Stresses lbs. per sq. in.	
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	Concrete	Steel
3"	201	151	115	89	69	53	41	31	23			540	18,500
3½	249	188	144	111	86	67	52	39	29			480	"
4	298	225	173	134	105	82	64	49	37	19		435	"
4½	348	263	203	158	124	97	76	59	45	24		400	"
5	398	302	232	181	142	112	88	69	53	29		375	"
6	496	376	290	227	179	141	112	87	68	38		330	"
7	597	453	351	275	217	172	136	107	84	48	22	305	"
8	697	530	410	321	254	202	160	127	99	57	27	280	"
9	798	607	470	369	292	232	185	147	115	68	34	260	"
10	896	682	529	415	329	262	209	165	130	77	38	245	"
11	998	761	590	464	368	293	234	186	147	87	45	230	"
12"	1098	836	650	510	405	323	258	205	162	97	50	220	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 750^{\#}/\text{sq. in.}$ $M = \frac{1}{12} w l^2$. Max. $f_s = 18{,}500^{\#}/\text{sq. in.}$

3-13-125 "Steelcrete" Expanded Metal. Area = 0.125 sq. in. per ft. of width.

Slab.	Span.												Unit Stresses lbs. per sq. in.	
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	Concrete	Steel.
3"	258	196	152	119	94	75	59	47	37	21				610	18,500
3½	319	243	188	148	117	94	75	59	47	28				545	"
4	382	291	226	178	142	113	91	73	58	35	19			490	"
4½	445	340	265	209	167	134	108	86	69	43	24			455	"
5	508	388	303	240	191	154	124	100	80	51	29			425	"
6	635	486	379	300	240	194	157	127	102	65	39	19		380	"
7	762	584	457	362	290	234	190	155	125	81	49	25		345	"
8	889	681	533	423	340	275	223	181	147	96	58	31		320	"
9	1018	782	612	486	390	316	257	210	171	111	69	37		300	"
10	1145	878	688	547	440	356	290	236	193	126	78	43	16	275	"
11	1275	979	767	610	491	398	324	265	216	142	89	50	20	265	"
12"	1403	1076	844	672	541	438	357	292	238	157	99	55	23	250	"

3-9-15 "Steelcrete" Expanded Metal. Area = 0.150 sq. in. per ft. of width.

Slab.	Span													Unit Stresses. lbs. per sq. in.	
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	Concrete	Steel.
3"	314	240	187	148	119	96	77	63	51	32	19				675	18,500
3½	389	298	233	185	148	120	97	79	64	42	25				605	"
4	464	357	279	222	179	145	118	96	79	52	32				550	"
4½	541	416	326	260	209	170	139	114	93	62	40	23			505	"
5	618	476	374	298	241	196	160	132	108	72	47	28			470	"
6	771	594	467	373	301	245	201	166	137	92	60	37	19		420	"
7	927	715	562	449	364	297	244	202	167	113	75	47	26		380	"
8	1081	834	656	525	425	348	286	236	195	133	89	56	31		350	"
9	1237	954	752	602	488	399	329	272	225	155	104	66	38		330	"
10	1394	1075	847	678	550	450	371	307	255	175	118	76	44	19	305	"
11	1550	1197	943	756	613	503	414	343	285	197	133	86	51	23	290	"
12"	1705	1316	1037	832	675	553	456	378	314	217	147	95	56	26	275	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 750\#/\text{sq. in}$ $\qquad M = \frac{1}{12} w l^2$ $\qquad$ Max. $f_s = 18{,}500\#/\text{sq. in.}$

3-9-175 "Steelcrete" Expanded Metal. Area = 0.175 sq. in. per ft. of width.

Slab.	Span.															Unit Stresses lbs. per sq. in.	
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	Concrete	Steel.
3"	369	283	222	177	143	116	95	78	64	42	27					740	18500
3½	458	353	277	222	179	146	120	100	82	55	36	23				660	"
4	547	422	332	266	215	176	145	120	99	68	46	29				595	"
4½	638	492	388	311	252	207	171	142	118	81	55	36	21			550	"
5	727	561	442	355	288	236	195	162	135	93	63	41	25			510	"
6	906	701	553	444	361	297	246	204	170	119	82	55	34	18		450	"
7	1087	841	664	534	434	357	296	247	206	144	100	67	43	23		410	"
8	1270	982	777	624	509	419	347	290	243	171	119	81	52	30		375	"
9	1452	1125	889	715	583	480	399	333	279	197	138	94	61	35		350	"
10	1635	1266	1001	807	657	542	450	375	315	223	157	108	71	42	19	330	"
11	1820	1410	1115	898	732	604	502	419	352	249	176	121	80	48	22	310	"
12"	2000	1550	1228	988	806	665	552	463	388	275	194	135	89	54	26	300	"

3-9-20 "Steelcrete" Expanded Metal. Area = 0.200 sq. in. per ft. of width

Slab	Span.																Unit Stresses lbs. per sq. in	
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	Concrete	Steel.
3"	397	306	241	193	156	128	105	87	72	49	33	20					750	17,400
3½	525	406	320	257	209	171	142	118	98	68	47	31	19				710	18,500
4	628	486	384	309	251	207	171	143	120	84	58	40	25				645	"
4½	731	566	448	360	294	242	201	168	141	100	70	48	32	19			595	"
5	836	647	512	413	337	278	231	193	162	115	82	57	38	23			555	"
6	1041	808	640	516	421	348	290	243	204	146	104	73	49	31			490	"
7	1251	970	770	621	508	420	350	294	248	177	127	90	62	40	22		445	"
8	1461	1133	899	726	594	491	410	344	290	208	150	106	73	48	27		410	"
9	1671	1297	1030	832	681	564	470	396	334	241	173	124	86	57	34		380	"
10	1880	1460	1159	936	767	635	530	446	377	271	196	140	98	65	39	18	360	"
11	2093	1624	1289	1042	854	707	591	497	421	304	220	158	111	74	45	22	340	"
12"	2302	1788	1420	1147	940	779	651	548	463	335	242	174	123	82	50	24	320	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 750^{\#}/sq.in$ $M = \frac{1}{12} w l^2$. Max. $f_s = 18{,}500^{\#}/sq.in.$

3-9-25 "Steelcrete" Expanded Metal. Area = 0.250 sq. in. per ft. of width.

Slab.	Span. 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Unit Stresses lbs. per sq. in. Concrete	Steel.
3"	428	330	261	209	170	139	115	95	79	55	37	24								750	15,100
3½	608	471	373	301	246	203	169	141	119	85	60	42	28							"	17,200
4	787	612	486	393	322	267	223	188	159	115	84	61	43	29	18					730	18,500
4½	916	712	566	458	376	312	262	221	187	136	100	73	52	36	23					675	"
5	1048	816	649	526	431	358	301	254	216	157	116	85	61	43	29					630	"
6	1309	1019	811	657	540	449	377	319	271	198	146	108	79	56	38	23				560	"
7	1571	1223	974	790	650	541	455	385	328	241	178	132	97	70	48	31	17			505	"
8	1834	1428	1137	923	760	632	531	450	384	282	209	156	115	83	58	38	21			460	"
9	2099	1637	1304	1058	872	726	610	518	441	325	242	181	134	98	69	45	26			430	"
10	2364	1840	1467	1191	980	817	687	583	497	366	273	204	151	111	78	52	30			405	"
11	2631	2051	1633	1325	1092	910	766	649	555	409	305	229	170	125	89	60	36			385	"
12"	2898	2258	1800	1461	1205	1004	845	717	612	452	338	253	189	138	99	67	40	19		360	"

3-9-30 "Steelcrete" Expanded Metal. Area = 0.300 sq. in. per ft. of width.

Slab.	Span. 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Unit Stresses lbs. per sq. in. Concrete	Steel.
3"	456	353	279	224	182	150	124	103	86	61	42	28								750	13,500
3½	645	500	397	320	262	217	181	152	128	92	66	47	33							"	15,300
4	866	674	536	435	357	297	249	211	179	131	97	71	52	37	25					"	17,000
4½	1102	858	685	556	458	382	322	273	233	173	129	97	73	54	39	26				"	18,500
5	1259	982	784	637	526	438	369	314	269	199	149	113	85	63	46	32	21			700	"
6	1574	1227	980	797	658	549	463	394	337	251	189	143	108	81	60	42	28			620	"
7	1891	1475	1179	959	792	662	559	475	408	304	229	174	133	100	74	54	37	23		560	"
8	2205	1721	1375	1119	924	773	653	556	476	355	269	205	156	118	88	64	44	28		515	"
9	2526	1970	1576	1283	1060	886	749	638	547	409	310	237	181	138	103	76	53	34		475	"
10	2842	2217	1774	1444	1193	998	844	719	617	461	350	267	205	156	117	86	60	39	22	445	"
11	3163	2472	1974	1608	1329	1113	941	802	688	515	391	299	230	175	132	98	69	46	26	420	"
12"	3488	2722	2179	1773	1466	1226	1037	884	759	568	432	331	254	194	147	109	77	51	30	400	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 750$ #/sq. in. $M = \frac{1}{12} w l^2$. Max. $f_s = 18{,}500$ #/sq. in.

3-9-35 "Steelcrete" Expanded Metal. Area = 0.350 sq. in. per ft. of width

Slab.	Span. 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Unit Stresses lbs. per sq. in. Concrete	Steel.
3"	480	372	294	236	193	159	132	110	92	65	46	31	20							750	12,200
3½	682	529	420	340	278	231	193	162	137	99	72	52	37	25						"	13,900
4	908	707	563	457	376	313	263	222	190	139	103	77	56	41	28					"	15,400
4½	1166	910	726	590	488	407	343	292	250	185	140	106	80	60	44	31	20			"	16,900
5	1446	1129	903	736	608	509	430	367	315	236	179	137	106	81	61	45	32	22		"	18,200
6	1835	1434	1148	936	775	649	549	469	403	302	231	178	137	106	81	61	44	31	19	675	18,500
7	2203	1723	1379	1125	931	781	661	565	486	366	280	216	168	130	100	76	56	40	26	610	"
8	2576	2013	1613	1315	1089	913	774	661	569	429	328	254	197	153	118	90	67	48	32	560	"
9	2948	2306	1846	1506	1248	1047	887	758	653	492	378	292	228	178	138	106	79	57	39	520	"
10	3320	2596	2079	1697	1406	1179	1000	855	736	556	427	330	258	201	156	120	90	66	45	490	"
11	3694	2891	2314	1890	1566	1313	1114	953	821	620	476	369	289	226	176	136	103	75	52	460	"
12"	4070	3185	2550	2082	1726	1449	1229	1050	906	684	526	408	319	250	195	150	114	84	58	440	"

3-6-40 "Steelcrete" Expanded Metal. Area = 0.400 sq. in. per ft. of width.

Slab.	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Unit Stresses lbs. per sq. in. Concrete	Steel.
3"	503	389	308	248	203	167	139	117	98	70	49	34	23							750	11,300
3½	713	554	441	356	292	243	203	171	145	106	77	56	40	28						"	12,800
4	954	743	592	481	396	330	278	236	201	148	111	83	62	45	32	21				"	14,200
4½	1219	952	760	619	511	427	361	307	263	196	148	113	86	65	48	35	24			"	15,500
5	1517	1185	948	773	640	536	454	387	333	250	191	147	113	88	67	50	37	25		"	16,800
6	2090	1636	1311	1070	888	745	632	541	467	353	271	211	166	130	102	79	60	45	32	730	18,500
7	2513	1968	1578	1289	1069	898	763	653	563	427	329	257	202	159	125	98	76	57	41	660	"
8	2938	2300	1844	1506	1250	1050	892	764	660	500	386	302	238	188	148	116	90	68	50	610	"
9	3368	2638	2116	1728	1434	1206	1024	878	758	576	444	348	275	217	172	135	105	81	60	565	"
10	3795	2970	2383	1946	1615	1359	1154	989	855	649	501	393	310	246	195	153	120	92	69	530	"
11	4218	3303	2652	2165	1798	1512	1285	1101	951	723	559	439	347	275	218	173	135	104	78	495	"
12"	4650	3640	2920	2388	1981	1666	1416	1214	1050	798	618	484	383	304	242	191	150	116	87	470	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 750$ #/sq. in $\qquad M = \frac{1}{12} w l^2$. $\qquad$ Max. $f_s = 18{,}500$ #/sq. in.

3-6-45 "Steelcrete" Expanded Metal. Area = 0.450 sq. in. per ft. of width

Slab	Span.																		Unit Stresses lbs. per sq. in.	
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel.
3"	521	404	320	258	211	174	145	122	102	73	52	37	25							750	10,400
3½	738	574	457	370	304	253	212	179	152	111	81	59	43	30	20					"	11,800
4	991	772	616	501	413	344	290	246	210	156	117	88	66	49	35	24				"	13,200
4½	1268	990	792	644	532	446	376	321	275	206	156	119	91	69	52	38	27			"	14,400
5	1574	1231	985	804	666	558	472	403	347	261	200	154	120	93	72	54	40	29	19	"	15,600
6	2255	1766	1417	1158	961	808	686	588	508	385	298	233	184	146	115	91	71	54	40	"	17,800
7	2823	2213	1776	1453	1207	1016	864	741	641	488	379	298	236	189	151	120	95	74	57	705	18,500
8	3305	2590	2080	1700	1413	1189	1011	868	751	572	444	350	278	222	178	142	113	88	68	650	"
9	3783	2963	2378	1948	1618	1362	1159	995	861	657	511	402	320	257	206	165	131	103	80	605	"
10	4255	3340	2680	2194	1823	1535	1306	1121	971	741	577	455	362	290	233	187	149	118	91	565	"
11	4743	3718	2983	2443	2031	1711	1456	1251	1083	827	643	508	405	325	261	210	168	133	104	530	"
12"	5225	4095	3290	2692	2240	1885	1605	1379	1194	911	710	560	447	359	289	232	186	148	115	505	"

3-6-50 "Steelcrete" Expanded Metal. Area = 0.500 sq. in. per ft. of width.

Slab	Span.																		Unit Stresses lbs. per sq. in.	
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel.
4"	1026	800	638	519	428	358	302	256	219	163	122	92	70	52	38	27				750	12,300
4½	1320	1030	824	672	556	465	393	335	288	216	164	126	97	74	56	42	30			"	13,500
5	1628	1273	1019	832	689	578	490	419	360	272	208	161	126	98	76	58	44	32	21	"	14,600
6	2340	1833	1471	1203	999	840	714	612	529	402	311	244	193	154	122	97	76	59	44	"	16,700
7	3131	2453	1973	1614	1342	1131	963	828	717	548	427	338	270	217	176	142	114	91	72	"	18,500
8	3660	2870	2305	1888	1570	1323	1127	969	840	642	502	397	318	256	207	167	135	108	86	690	"
9	4193	3288	2643	2166	1801	1518	1294	1112	964	739	577	457	366	296	239	194	157	126	101	640	"
10	4725	3705	2977	2438	2029	1710	1458	1254	1087	833	651	516	413	334	271	220	178	143	114	600	"
11	5263	4128	3321	2721	2263	1908	1627	1399	1213	929	727	577	463	374	304	247	200	162	130	565	"
12"	5790	4545	3650	2991	2490	2100	1790	1540	1335	1024	801	635	510	412	335	273	221	179	143	540	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 750$ #/sq. in. $M = \frac{1}{12} w l^2$. Max. $f_s = 18{,}500$ #/sq. in.

3-6-55 "Steelcrete" Expanded Metal. Area = 0.550 sq. in. per ft. of width.																				Unit Stresses lbs. per sq. in.	
Slab	Span.																				
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel.
4"	918	715	570	462	380	317	266	225	192	141	105	78	58	42	29	19				750	11,000
4½	1199	936	748	608	502	419	354	301	258	192	145	110	83	63	46	33	22			"	12,100
5	1510	1180	945	770	637	534	452	385	331	249	190	146	113	87	66	50	36	25		"	13,200
6	2215	1735	1391	1136	943	793	673	577	498	378	292	228	180	142	112	88	68	52	38	"	15,200
7	3028	2373	1906	1560	1297	1092	930	799	691	528	411	325	259	208	167	134	108	85	67	"	17,100
8	3870	3035	2440	1999	1663	1402	1196	1028	892	684	535	424	341	276	224	182	148	120	96	740	18,500
9	4448	3493	2809	2303	1918	1617	1378	1186	1029	790	618	492	395	320	261	213	173	141	113	690	"
10	5040	3955	3180	2607	2173	1831	1560	1344	1166	895	701	558	449	364	297	242	198	161	130	640	"
11	5628	4418	3553	2913	2424	2046	1746	1503	1304	1001	785	625	504	409	334	273	223	182	148	605	"
12"	6215	4880	3925	3220	2680	2260	1930	1660	1441	1108	869	692	558	453	370	303	248	202	165	575	"

3-6-60 "Steelcrete" Expanded Metal. Area = 0.600 sq. in. per ft. of width																				Unit Stresses lbs. per sq. in.	
Slab.	Span.																				
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel.
4"	941	734	584	474	391	325	274	232	198	146	109	81	60	44	31	21				750	10,400
4½	1235	964	770	627	518	433	366	311	267	199	151	115	88	66	49	36	25			"	11,500
5	1553	1214	972	793	656	550	466	397	342	257	197	152	117	91	70	53	39	27	18	"	12,500
6	2278	1785	1431	1170	971	817	693	595	513	390	302	236	187	148	117	92	72	55	41	"	14,400
7	3111	2441	1961	1604	1334	1124	957	823	713	545	425	336	268	216	174	140	113	90	71	"	16,100
8	4045	3175	2552	2091	1742	1470	1253	1079	936	719	563	448	361	292	238	195	159	129	105	"	17,800
9	4848	3803	3058	2508	2088	1765	1507	1298	1127	868	681	543	439	357	292	240	198	162	133	720	18,500
10	5480	4305	3465	2840	2365	1997	1705	1470	1277	983	772	616	498	406	333	274	225	185	152	675	"
11	6128	4813	3873	3175	2646	2234	1908	1645	1428	1100	865	691	559	456	374	308	255	210	172	635	"
12"	6770	5320	4280	3510	2925	2470	2110	1820	1580	1217	957	765	619	506	415	342	283	233	192	600	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 750$ #/sq. in. $M = \frac{1}{12} w l^2$. Max. $f_s = 18{,}500$ #/sq. in.

3-6-75 "Steelcrete" Expanded Metal. Area = 0.750 sq. in. per ft. of width.

Slab.	Span.																		Unit Stresses lbs. per sq. in.	
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel.
5"	1486	1162	930	757	626	524	444	378	325	244	186	143	110	85	64	48	35	24		750	10,400
6	2238	1754	1406	1149	953	801	681	583	503	382	295	231	182	144	114	90	70	53	39	"	12,100
7	3118	2443	1963	1608	1337	1126	959	824	714	546	425	337	269	216	175	141	113	90	71	"	13,700
8	4090	3208	2580	2113	1760	1485	1266	1090	946	727	570	454	365	296	242	198	162	132	106	"	15,100
9	5173	4068	3273	2686	2238	1889	1614	1391	1210	932	734	587	476	389	320	264	218	181	149	"	16,500
10	6350	4995	4020	3303	2754	2327	1990	1718	1495	1154	911	731	595	488	403	336	280	234	195	"	17,800
11	7403	5823	4688	3853	3215	2718	2325	2008	1748	1353	1069	860	701	577	479	399	334	280	235	730	18,500
12	8210	6460	5205	4275	3568	3018	2580	2229	1940	1502	1188	955	779	642	533	444	372	313	263	690	"
13	9013	7088	5713	4693	3918	3313	2836	2448	2132	1652	1307	1051	857	706	588	490	412	346	291	655	"
14	9825	7725	6225	5115	4270	3613	3088	2668	2325	1799	1425	1146	935	771	641	536	450	379	319	630	"
15	10633	8363	6733	5533	4623	3908	3343	2888	2515	1951	1543	1243	1014	836	696	582	489	411	347	600	"
16"	11440	9000	7250	5960	4975	4210	3600	3110	2710	2100	1662	1341	1093	902	750	628	528	444	375	580	"

3-6-100 "Steelcrete" Expanded Metal. Area = 1.000 sq. in. per ft. of width.

Slab.	Span.																		Unit Stresses lbs. per sq. in.	
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel.
5"	1613	1262	1010	824	683	573	486	415	357	269	206	160	124	97	75	57	43	31	21	750	8,600
6	2447	1918	1540	1259	1046	881	749	643	556	423	329	259	205	164	131	104	83	65	50	"	10,100
7	3413	2681	2153	1764	1468	1239	1056	909	789	605	473	376	302	244	199	162	132	107	86	"	11,400
8	4485	3520	2835	2325	1938	1636	1398	1204	1046	806	634	506	409	334	274	226	187	154	126	"	12,600
9	5678	4463	3593	2950	2463	2080	1778	1534	1336	1032	815	654	531	436	361	300	250	209	174	"	13,800
10	6970	5480	4415	3627	3030	2564	2193	1893	1649	1276	1010	813	663	547	454	379	319	268	225	"	14,800
11	8363	6583	5303	4363	3643	3083	2642	2282	1990	1543	1223	987	808	668	557	467	394	334	283	"	15,900
12	9900	7795	6285	5170	4320	3660	3132	2710	2363	1835	1459	1179	966	802	671	565	478	407	346	"	16,900
13	11478	9038	7288	5993	5008	4248	3638	3148	2748	2138	1700	1377	1131	940	788	666	566	482	413	"	17,900
14	12955	10195	8235	6795	5665	4800	4115	3565	3110	2420	1925	1561	1284	1069	897	759	646	552	474	740	18,500
15	14023	11043	8913	7333	6133	5193	4453	3858	3368	2622	2087	1693	1392	1159	973	824	702	600	515	710	"
16"	15110	11900	9600	7900	6605	5600	4800	4155	3630	2825	2250	1825	1501	1250	1050	889	757	648	556	680.	"

"Steelcrete" MESH SLAB TABLES

for use with

GRAVEL OR STONE CONCRETE

Maximum Stress in Steel=16,000 lbs. per sq. inch. Maximum Stress in Concrete=650 lbs. per sq. inch

Maximum Bending Moment $= M = \frac{1}{12} wl^2$.

where

w=total load per sq. ft. l=center to center span

3-13-075 "Steelcrete" Expanded Metal. Area = 0.075 sq. in. per ft. of width.

Slab	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	Unit stresses lbs. per sq. in. Concrete	Steel
3"	119	86	63	45	32	22				395	16,000
3½	148	108	79	58	41	29	19			350	"
4	178	130	96	71	51	36	25			320	"
4½	208	153	113	84	62	44	30	19		300	"
5	239	176	131	97	72	52	36	24		280	"
6	299	220	164	123	91	66	47	31		250	"
7	360	266	199	149	112	82	59	40	25	225	"
8	420	311	233	175	131	97	70	48	30	210	"
9	482	357	268	202	152	113	82	57	36	190	"
10	542	402	302	228	171	128	93	65	42	180	"
11	603	448	337	255	192	143	105	74	48	170	"
12"	664	493	371	281	212	159	116	82	54	165	"

3-13-10 "Steelcrete" Expanded Metal. Area = 0.100 sq. in. per ft. of width.

Slab	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	Unit stresses lbs. per sq. in. Concrete	Steel
3"	169	126	95	72	55	41	30	22				465	16,000
3½	210	156	118	90	69	52	39	28				415	"
4	251	188	143	109	84	64	48	36	25			375	"
4½	293	220	168	129	99	76	58	43	31			345	"
5	335	252	192	148	115	88	68	51	37			325	"
6	419	315	241	186	144	112	86	65	48	23		290	"
7	504	380	291	226	176	137	106	81	61	30		265	"
8	589	444	341	264	206	161	125	96	72	36		245	"
9	674	510	391	304	237	186	145	112	85	43		225	"
10	759	573	440	342	268	210	163	126	96	50		210	"
11	845	639	492	383	299	235	184	142	108	57	20	200	"
12"	930	704	541	421	330	259	203	157	120	63	23	190	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 650$#/sq. in. $M = \frac{1}{12} w l^2$. Max. $f_s = 16{,}000$#/sq. in.

3-13-125 "Steelcrete" Expanded Metal. Area = 0.125 sq. in. per ft. of width.

Slab.	Span. 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	Unit stresses lbs. per sq. in. Concrete	Steel.
3"	218	164	126	98	76	60	46	36	27				525	16,000
3½	270	204	157	122	96	75	59	45	35				470	"
4	323	245	189	147	116	91	72	56	43	24			430	"
4½	377	286	221	173	137	108	85	67	52	30			390	"
5	431	327	253	199	157	125	99	78	61	35			365	"
6	538	410	317	249	198	157	125	99	78	46	23		325	"
7	647	493	383	301	239	191	153	122	97	58	30		300	"
8	755	575	447	352	280	224	179	143	114	69	37		275	"
9	865	660	513	404	322	258	207	166	132	81	44		260	"
10	972	743	578	456	363	291	233	187	149	92	51	20	240	"
11	1083	827	644	508	405	325	261	210	168	104	58	24	225	"
12"	1193	911	710	560	447	358	289	232	186	115	65	28	215	"

3-9-15 "Steelcrete" Expanded Metal. Area = 0.150 sq. in. per ft. of width.

Slab.	Span. 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	Unit stresses lbs. per sq. in. Concrete	Steel.
3"	266	202	157	123	98	78	62	49	39	23				585	16,000
3½	330	251	195	154	122	98	78	62	50	30				520	"
4	395	302	235	185	148	119	95	77	61	38	21			475	"
4½	460	352	274	217	173	140	113	91	73	46	26			435	"
5	526	403	315	249	200	161	130	105	85	54	32			405	"
6	657	503	393	312	250	202	164	133	108	70	42	22		360	"
7	790	605	474	377	303	245	199	162	132	86	53	29		325	"
8	922	708	554	440	354	287	234	191	155	102	63	35		305	"
9	1056	810	636	506	407	330	269	220	180	119	75	42		285	"
10	1188	913	715	570	459	372	304	249	204	134	85	49	21	265	"
11	1322	1015	797	635	511	415	339	278	228	151	96	56	25	250	"
12"	1455	1117	877	699	563	458	374	306	252	167	107	62	28	240	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft

$M = \frac{1}{12} w l^2$.

Max. $f_c = 650$ #/sq. in. Max. $f_s = 16{,}000$ #/sq. in.

3-9-175 "Steelcrete" Expanded Metal. Area = 0.175 sq. in. per ft. of width.

Slab.	Span. 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	Unit Stresses lbs. per sq. in. Concrete.	Steel.
3"	314	240	187	148	118	95	77	62	50	32	18				640	16000
3½	390	299	234	186	149	121	98	80	65	42	25				570	"
4	466	358	280	223	180	146	119	97	79	52	33	18			515	"
4½	544	418	328	262	211	171	140	115	94	63	40	23			475	"
5	620	477	374	298	240	196	160	131	108	72	46	27			440	"
6	774	596	468	374	303	247	202	167	137	93	61	37	19		390	"
7	928	716	562	450	364	297	244	201	166	113	75	47	25		355	"
8	1085	836	658	526	426	349	287	237	196	134	90	57	32		325	"
9	1242	957	754	603	489	400	330	272	226	155	104	66	38		305	"
10	1398	1078	849	681	552	451	372	308	256	176	119	76	44	19	285	"
11	1555	1200	946	758	615	504	415	344	286	197	133	86	50	22	270	"
12"	1712	1321	1042	835	678	555	458	380	316	218	148	96	57	25	260	"

3-9-20 "Steelcrete" Expanded Metal. Area = 0.200 sq. in. per ft. of width.

Slab	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	Unit stresses lbs. per sq. in. Concrete	Steel
3"	339	260	204	162	130	105	86	70	57	37	23					650	15,100
3½	448	345	271	216	175	142	117	96	79	53	35	21				605	16,000
4	536	413	325	260	211	172	142	117	97	66	44	28				555	"
4½	625	482	380	304	247	202	167	138	114	79	53	34	20			515	"
5	714	551	435	348	283	232	192	159	132	91	62	41	24			480	"
6	891	688	543	436	354	291	240	200	166	116	80	53	32			425	"
7	1070	828	654	525	427	351	291	242	202	142	98	66	42	23		385	"
8	1250	966	764	614	500	411	341	284	238	167	116	79	50	28		355	"
9	1431	1107	876	704	574	472	392	327	274	193	135	92	59	34		330	"
10	1611	1246	985	793	647	532	442	369	309	218	153	104	68	39		310	"
11	1793	1387	1098	883	721	594	493	412	346	244	172	118	77	46	21	295	"
12"	1972	1526	1208	972	793	654	543	454	381	269	190	131	86	51	23	280	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs per sq. ft.

Max. $f_c = 650^{\#}/$sq. in. $M = \frac{1}{12} w l^2$ Max. $f_s = 16{,}000^{\#}/$sq. in.

3-9-25 "Steelcrete" Expanded Metal. Area = 0.250 sq. in. per ft. of width.																		Unit stresses. lbs. per sq. in.	
Slab.	Span.																		
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"		Concrete	Steel.
3"	366	281	221	176	142	116	95	78	64	43	28							650	13,100
3½	521	403	318	255	208	170	141	117	97	68	47	31	19					"	14,900
4	675	523	414	333	272	224	187	156	131	93	66	46	31	19				635	16,000
4½	786	609	483	389	318	263	219	184	155	110	79	55	38	24				585	"
5	898	697	553	446	365	302	252	211	178	128	92	65	45	29				550	"
6	1121	871	691	558	457	378	316	265	224	161	117	83	58	38	23			485	"
7	1347	1046	831	671	551	456	381	321	272	196	142	103	72	49	30			435	"
8	1572	1221	970	785	643	533	446	376	318	230	168	121	86	58	36	19		400	"
9	1800	1399	1112	900	740	613	513	432	366	266	194	141	100	69	44	24		370	"
10	2025	1575	1252	1013	832	690	578	487	413	300	219	160	114	79	51	28		350	"
11	2254	1753	1394	1128	926	769	644	543	461	335	246	179	129	89	58	33		330	"
12"	2485	1931	1536	1244	1021	848	710	600	509	371	272	198	143	99	65	37		320	"

3-9-30 "Steelcrete" Expanded Metal. Area = 0.300 sq. in. per ft. of width.																			Unit stresses lbs. per sq. in.	
Slab.	Span.																			
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	Concrete	Steel.
3"	391	301	237	189	153	125	103	85	71	48	32	20							650	11,700
3½	554	428	339	272	221	182	151	126	105	74	52	35	22						"	13,300
4	744	578	458	370	303	251	210	176	149	107	77	55	38	25					"	14,700
4½	945	736	585	474	389	323	271	229	194	142	104	76	55	39	26				"	16,000
5	1080	841	669	542	446	371	311	263	224	164	121	89	65	46	31	19			600	"
6	1350	1051	837	679	559	465	390	331	281	207	153	113	83	60	41	26			535	"
7	1623	1263	1007	817	673	561	471	399	341	251	187	139	103	75	53	35	20		485	"
8	1893	1475	1176	955	786	655	551	467	398	294	219	164	122	89	63	42	25		445	"
9	2168	1691	1348	1094	902	752	633	537	458	339	253	190	142	104	74	50	31		410	"
10	2443	1903	1517	1233	1015	847	713	605	517	382	286	214	160	118	84	58	35		385	"
11	2722	2122	1692	1374	1133	946	796	676	578	428	320	241	181	134	96	66	42	21	365	"
12"	2995	2335	1862	1514	1248	1041	877	745	636	472	354	266	199	148	107	74	47	24	345	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 650\,\#/\text{sq.in}$ $\quad$ $M = \frac{1}{12} w l^2$. $\quad$ Max. $f_s = 16{,}000\,\#/\text{sq.in.}$

3-9-35 "Steelcrete" Expanded Metal. Area = 0.350 sq. in. per ft. of width.

Slab.	Span.																			Unit stresses lbs. per sq. in.	
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel.
3"	412	317	250	200	162	133	109	91	75	52	35	22								650	10,600
3½	586	453	359	289	236	194	162	135	113	80	57	39	26							"	12,000
4	780	606	482	389	319	264	221	186	158	114	83	60	42	29						"	13,400
4½	1005	784	624	506	416	346	291	246	210	154	114	84	62	45	31	20				"	14,600
5	1245	971	775	630	519	433	365	310	265	196	147	111	83	62	45	31	20			"	15,800
6	1577	1230	982	799	659	551	464	395	338	251	189	143	109	81	60	42	28			585	16,000
7	1895	1479	1181	961	794	664	561	477	409	305	230	175	133	101	75	54	37	23		525	"
8	2213	1728	1381	1123	929	776	656	558	478	357	270	206	157	119	89	65	45	28		485	"
9	2532	1978	1580	1287	1063	889	752	640	549	410	311	238	182	138	104	76	53	34	19	450	"
10	2854	2226	1781	1450	1198	1003	847	722	620	463	351	269	206	157	118	87	61	40	22	425	"
11	3175	2482	1983	1616	1336	1118	945	806	692	518	393	301	231	177	133	99	70	46	27	400	"
12"	3500	2733	2187	1780	1472	1232	1042	888	763	571	434	333	256	195	148	110	78	52	30	380	"

3-6-40 "Steelcrete" Expanded Metal. Area = 0.400 sq. in. per ft. of width.

Slab.	Span.																			Unit stresses lbs. per sq. in.	
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel.
3"	431	333	263	211	171	140	116	96	80	56	38	25								650	9,750
3½	612	474	376	303	248	205	170	143	120	86	61	43	29	18						"	11,100
4	821	638	508	411	337	280	235	198	168	122	89	65	47	32	21					"	12,300
4½	1049	818	652	529	436	363	305	258	220	162	121	90	67	49	34	23				"	13,400
5	1307	1020	814	662	547	457	385	327	280	208	157	119	90	68	50	35	24			"	14,600
6	1797	1404	1124	915	757	634	536	457	393	295	225	173	133	102	78	58	42	28		630	16,000
7	2161	1688	1352	1102	912	764	647	553	475	357	273	210	163	126	96	73	53	37	24	570	"
8	2527	1976	1580	1290	1068	895	758	648	556	419	320	247	192	149	114	87	64	45	30	525	"
9	2898	2266	1813	1479	1226	1027	870	744	640	482	369	286	222	173	133	102	76	55	37	485	"
10	3265	2553	2043	1665	1380	1158	981	839	722	545	417	323	251	196	152	116	87	63	42	455	"
11	3633	2841	2275	1856	1538	1289	1093	934	805	607	466	361	282	220	170	131	98	72	49	425	"
12"	3995	3128	2505	2043	1694	1421	1204	1030	887	670	514	398	311	243	189	145	109	80	55	405	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 650^{\#}/\text{sq. in.}$ $M = \frac{1}{12} w l^2$. Max $f_s = 16{,}000^{\#}/\text{sq. in.}$

3-6-45 "Steelcrete" Expanded Metal. Area = 0.450 sq. in. per ft. of width.

Slab.	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Unit stresses lbs. per sq. in. Concrete	Steel.
3"	447	345	273	219	178	146	121	101	84	58	40	27								650	9,040
3½	635	493	390	315	257	213	178	149	126	90	65	46	31	20						"	10,250
4	852	663	528	427	351	292	245	207	176	128	94	69	50	35	24					"	11,400
4½	1092	851	679	552	454	379	319	271	231	171	127	96	72	53	38	26				"	12,500
5	1356	1058	846	688	568	475	401	341	293	218	165	126	96	72	54	39	27			"	13,500
6	1945	1520	1217	993	823	690	584	499	430	324	248	192	149	116	90	69	51	37	25	"	15,400
7	2431	1902	1524	1245	1032	867	735	629	543	410	316	246	193	151	119	92	70	52	37	610	16,000
8	2841	2225	1783	1456	1208	1014	861	737	636	482	371	289	227	179	140	109	84	63	45	560	"
9	3256	2548	2042	1668	1385	1163	988	846	730	553	426	333	262	207	163	127	99	75	54	520	"
10	3665	2873	2303	1880	1560	1311	1114	954	823	624	480	377	296	234	184	144	112	85	62	490	"
11	4083	3201	2565	2096	1741	1463	1242	1064	919	697	539	421	332	263	208	163	127	97	72	460	"
12"	4500	3525	2828	2310	1917	1611	1369	1173	1013	769	594	465	367	290	230	181	141	108	80	435	"

3-6-50 "Steelcrete" Expanded Metal. Area = 0.500 sq. in. per ft. of width.

Slab.	Span. 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Unit stresses lbs. per sq. in. Concrete	Steel.
4"	882	687	547	443	364	303	254	215	183	134	99	73	54	38	26					650	10,700
4½	1137	886	707	575	474	396	334	283	242	180	135	101	77	57	41	29	19			"	11,700
5	1403	1096	876	713	590	493	416	355	304	227	172	132	101	77	58	42	30	19		"	12,600
6	2022	1581	1266	1033	857	719	609	521	449	339	260	202	158	124	96	74	56	41	28	"	14,500
7	2693	2111	1693	1383	1149	966	821	704	608	463	358	281	222	176	140	111	87	67	50	"	16,000
8	3150	2468	1980	1620	1345	1131	961	824	713	542	420	330	261	208	165	131	103	80	61	595	"
9	3613	2830	2270	1858	1543	1298	1104	948	820	624	484	381	302	241	192	153	121	94	72	550	"
10	4070	3185	2560	2094	1739	1463	1245	1068	924	704	546	430	341	272	218	173	137	107	82	520	"
11	4533	3553	2853	2333	1939	1632	1388	1191	1031	785	610	481	382	305	244	195	155	122	94	490	"
12"	4990	3910	3140	2570	2135	1796	1528	1312	1135	866	672	530	421	337	270	215	171	135	104	465	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 650$ #/sq. in. $M = \frac{1}{12} w l^2$. Max. $f_s = 16,000$ #/sq. in.

3-6-55 "Steelcrete" Expanded Metal. Area = 0.550 sq. in. per ft. of width.																				Unit stresses lbs. per sq. in.	
Slab	Span																				
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel.
4"	790	613	487	394	323	268	224	189	160	116	84	61	43	29	19					650	9,600
4½	1031	804	640	519	427	356	299	253	216	159	118	88	65	47	33	21				"	10,500
5	1300	1014	810	659	544	454	383	326	279	207	156	118	89	67	49	35	23			"	11,500
6	1909	1493	1195	974	807	676	573	489	421	317	242	187	145	113	87	66	49	35	23	"	13,200
7	2611	2044	1640	1340	1113	935	794	680	588	446	345	270	213	168	133	105	82	62	46	"	14,800
8	3330	2610	2095	1715	1425	1199	1020	876	758	578	448	353	281	225	180	144	114	90	69	640	16,000
9	3833	3006	2413	1976	1641	1382	1176	1010	875	668	520	410	326	261	210	168	134	106	83	595	"
10	4340	3400	2733	2235	1859	1565	1333	1145	991	757	589	465	371	298	239	193	154	122	95	555	"
11	4848	3803	3053	2502	2080	1753	1491	1282	1110	848	661	523	417	335	270	217	175	139	109	525	"
12"	5350	4200	3375	2761	2298	1935	1648	1416	1226	937	731	578	462	371	299	241	194	155	122	495	"

3-6-60 "Steelcrete" Expanded Metal. Area = 0.600 sq. in. per ft. of width.																				Unit stresses lbs. per sq. in.	
Slab.	Span.																				
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel.
4"	809	629	500	404	332	275	230	194	165	120	87	64	45	31	20					650	9,000
4½	1063	828	660	536	442	368	309	262	224	165	123	92	68	50	35	24				"	10,000
5	1338	1044	834	678	560	468	395	336	288	215	162	123	94	71	52	38	26			"	10,800
6	1965	1535	1230	1004	831	697	591	505	435	328	251	195	152	118	92	70	52	38	26	"	12,500
7	2688	2105	1690	1382	1146	964	819	703	607	461	357	280	221	176	140	110	87	67	50	"	14,000
8	3490	2738	2200	1800	1496	1260	1073	921	798	609	474	375	299	240	193	155	124	99	77	"	15,400
9	4178	3278	2630	2156	1793	1511	1288	1107	960	735	574	455	364	294	238	193	156	125	100	620	16,000
10	4720	3705	2975	2438	2030	1710	1458	1254	1087	833	651	516	413	334	271	220	178	143	114	585	"
11	5283	4143	3333	2729	2271	1914	1633	1404	1218	933	730	579	465	376	305	248	202	163	131	550	"
12"	5835	4580	3680	3015	2510	2118	1804	1552	1346	1032	808	642	515	416	338	275	224	181	146	520	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 650\ \#/\text{sq. in.}$ $M = \frac{1}{12} w l^2$. Max. $f_s = 16{,}000\ \#/\text{sq. in.}$

3-6-75 "Steelcrete" Expanded Metal. Area = 0.750 sq. in. per ft. of width.

Slab	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Unit stresses lbs. per sq. in. Concrete	Steel
5"	1281	999	798	648	535	446	377	320	274	203	153	116	87	65	48	34	22			650	9,000
6	1929	1508	1208	985	815	684	579	495	426	321	246	190	148	115	89	68	50	36	24	"	10,500
7	2688	2105	1688	1382	1147	964	819	703	607	461	357	280	221	176	140	110	87	67	50	"	11,900
8	3530	2768	2222	1820	1513	1275	1085	932	808	617	481	380	303	243	196	158	127	101	79	"	13,100
9	4468	3508	2818	2308	1923	1623	1383	1190	1033	793	620	494	397	321	262	214	174	141	114	"	14,300
10	5485	4310	3465	2845	2370	2000	1708	1471	1279	984	773	617	499	406	333	274	226	186	152	"	15,400
11	6383	5018	4038	3313	2763	2333	1993	1718	1493	1152	906	725	587	481	395	327	271	224	185	630	16,000
12	7085	5565	4480	3675	3065	2590	2212	1908	1660	1280	1007	806	654	535	440	364	302	250	207	600	"
13	7778	6108	4918	4038	3363	2843	2429	2096	1823	1405	1108	888	720	589	486	402	334	277	230	565	"
14	8465	6655	5360	4395	3665	3097	2645	2285	1985	1532	1209	968	786	643	531	439	365	304	252	545	"
15	9173	7208	5803	4763	3973	3355	2868	2475	2151	1661	1309	1049	852	699	577	478	398	331	275	520	"
16"	9860	7760	6245	5130	4275	3615	3088	2665	2320	1790	1411	1132	919	754	622	516	430	358	297	500	"

3-6-100 "Steelcrete" Expanded Metal. Area = 1.000 sq. in. per ft. of width.

Slab	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Unit stresses lbs. per sq. in. Concrete	Steel
5"	1391	1087	868	707	584	489	412	351	301	225	171	130	99	76	57	41	29	19		650	7,500
6	2113	1653	1325	1081	897	753	639	547	472	357	275	214	168	132	104	81	62	46	33	"	8,700
7	2948	2313	1856	1518	1263	1063	905	776	672	513	399	315	250	200	161	129	103	81	63	"	9,900
8	3870	3038	2441	2000	1665	1404	1196	1030	893	684	536	425	341	276	224	182	148	120	96	"	10,900
9	4908	3853	3103	2543	2118	1789	1527	1316	1143	880	692	552	446	363	298	245	202	166	136	"	11,900
10	6015	4735	3810	3125	2607	2203	1883	1624	1413	1090	859	687	558	457	377	312	259	215	179	"	12,900
11	7233	5683	4583	3763	3138	2653	2268	1961	1705	1319	1042	838	682	561	465	387	323	271	227	"	13,800
12	8560	6740	5430	4465	3725	3152	2699	2330	2030	1573	1245	1003	819	675	562	470	395	333	281	"	14,700
13	9928	7818	6298	5178	4323	3658	3133	2708	2363	1832	1453	1173	959	794	662	556	469	397	337	"	15,500
14	11185	8805	7095	5835	4875	4130	3535	3058	2665	2070	1644	1328	1089	901	753	633	535	454	386	640	16,000
15	12113	9533	7683	6313	5278	4468	3828	3313	2888	2243	1781	1438	1179	977	817	687	581	494	420	615	"
16"	13050	10260	8280	6810	5690	4815	4125	3565	3110	2418	1920	1552	1272	1055	881	742	628	533	454	590	"

"Steelcrete" MESH SLAB TABLES

for use with

CINDER CONCRETE

Maximum Stress in Steel = 16,000 lbs. per sq. inch. Maximum Stress in Concrete = 300 lbs. per sq. inch

Maximum Bending Moment = $M = \frac{1}{12}wl^2$.

where

w = total load per sq. ft. l = center to center span

3-13-075 "Steelcrete" Expanded Metal. Area = 0.075 sq. in per ft. of width.

Slab	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	Unit Stresses lbs. per sq. in. Concrete	Steel
3"	121	89	67	50	38	28	20				265	16,000
3½	151	112	84	64	48	36	26	19			235	"
4	182	136	103	79	60	45	34	25			215	"
4½	213	159	121	92	71	54	41	30	21		200	"
5	244	182	138	106	82	62	47	35	25		185	"
6	305	229	174	134	103	80	61	45	33	14	165	"
7	368	277	212	163	126	98	75	57	42	19	150	"
8	430	323	247	191	148	115	89	67	50	23	135	"
9	494	372	285	220	172	133	103	79	59	28	125	"
10	555	418	320	248	193	150	116	89	67	33	120	"
11	619	467	358	278	217	169	131	101	76	38	110	"
12"	682	515	395	306	239	187	145	112	84	42	105	"

3-13-10 "Steelcrete" Expanded Metal. Area = 0.100 sq. in. per ft of width

Slab	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	Unit Stresses lbs. per sq. in. Concrete	Steel
3"	157	118	90	69	54	41	32	24					300	15,100
3½	209	158	122	95	74	58	45	35	27				280	16,000
4	252	191	148	115	91	72	57	45	35	19			255	"
4½	294	223	173	135	107	85	67	53	41	24			235	"
5	336	255	198	155	123	97	77	61	48	28			220	"
6	420	320	248	195	155	123	98	78	62	37			195	"
7	507	387	301	237	188	150	120	96	77	46	25		175	"
8	593	452	352	277	221	177	142	113	90	55	30		160	"
9	678	518	403	318	254	204	164	131	105	65	36		150	"
10	765	584	455	359	287	230	185	149	119	74	42	18	140	"
11	853	651	508	401	320	258	208	167	134	84	48	22	130	"
12"	938	717	559	442	353	284	229	185	148	93	54	24	125	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs per sq. ft.

Max. $f_c = 300\#/\text{sq. in.}$ $M = \frac{1}{12} w l^2$. Max. $f_s = 16{,}000\#/\text{sq. in.}$

Slab	3-13-125 "Steelcrete" Expanded Metal.	Area = 0.125 sq. in. per ft of width												Unit Stresses lbs. per sq. in	
	Span														
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	Concrete	Steel.
3"	170	129	99	76	60	46	36	28	21					300	13,100
3½	245	187	145	114	90	72	57	46	36	21				"	14,900
4	320	245	191	152	121	98	79	64	52	33	19			290	16,000
4½	374	286	224	177	142	115	93	76	61	39	24			265	"
5	427	328	256	204	163	132	107	87	71	46	28			250	"
6	535	410	321	256	205	166	136	111	90	59	37	20		220	"
7	644	495	388	309	249	202	165	135	111	73	47	27		200	"
8	753	579	454	362	292	237	194	159	131	87	56	33		185	"
9	864	664	522	416	336	274	224	184	152	102	66	40	20	170	"
10	972	748	588	469	379	308	253	208	171	115	75	45	23	160	"
11	1082	834	655	523	423	345	283	233	192	130	85	52	27	150	"
12"	1193	918	723	577	466	380	312	257	212	143	94	58	30	140	"

Slab	3-9-15 "Steelcrete" Expanded Metal.	Area = 0.150 sq. in. per ft. of width													Unit Stresses. lbs. per sq. in.	
	Span															
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	Concrete	Steel.
3"	182	138	106	83	65	51	40	31	24						300	11,700
3½	262	200	155	123	98	78	63	50	40	24					"	13,300
4	356	273	214	170	137	111	91	74	60	40	25				"	14,800
4½	453	349	274	219	177	145	119	98	81	55	36	23			"	16,000
5	518	399	314	251	203	166	137	113	93	64	43	27			275	"
6	648	500	394	315	256	209	172	143	118	81	55	35	20		245	"
7	779	602	475	381	309	253	209	174	145	100	68	45	27		220	"
8	912	704	555	446	362	297	246	204	170	118	81	54	33		205	"
9	1045	808	638	512	417	343	283	236	197	138	95	64	40	21	190	"
10	1178	910	719	578	470	386	320	266	223	156	108	72	45	25	175	"
11	1313	1015	803	645	525	432	358	298	250	175	122	82	53	29	165	"
12"	1446	1119	885	711	579	476	395	329	275	194	135	91	59	33	160	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 300\#/\text{sq. in.}$ $\quad M = \frac{1}{12} w l^2.$ $\quad$ Max. $f_s = 16{,}000\#/\text{sq. in.}$

3-9-175 "Steelcrete" Expanded Metal. Area = 0.175 sq. in. per ft. of width.

Slab.	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	Unit Stresses lbs. per sq. in. Concrete	Steel.
3"	193	146	113	88	70	55	44	34	26	15						300	10650
3½	278	212	166	131	105	84	68	55	44	28	16					"	12100
4	374	287	226	180	145	118	97	79	65	43	28	16				"	13400
4½	481	371	292	234	190	156	128	106	88	61	41	26	15			"	14650
5	600	464	367	295	241	198	164	137	114	80	56	38	24			"	15850
6	759	588	465	374	305	251	209	175	146	104	73	50	33	19		265	16000
7	913	707	560	451	368	304	253	212	178	127	90	63	42	26		240	"
8	1067	827	655	528	431	357	297	249	209	149	106	74	50	31	16	220	"
9	1222	948	752	606	496	410	342	287	241	173	123	87	60	38	21	205	"
10	1380	1070	848	684	560	463	386	324	273	196	140	99	68	44	25	190	"
11	1537	1193	945	764	625	517	431	363	306	220	158	112	78	51	29	180	"
12"	1693	1315	1042	842	689	570	475	399	337	242	174	124	86	56	33	170	"

3-9-20 "Steelcrete" Expanded Metal. Area = 0.200 sq in per ft of width

Slab	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	Unit Stresses lbs per sq. in Concrete	Steel
3"	201	153	118	93	73	58	46	36	29								300	9,700
3½	290	222	173	137	110	89	72	58	47	30							"	11,100
4	392	302	237	189	153	125	102	84	69	47	31						"	12,300
4½	503	389	307	246	200	164	136	113	94	65	45	29					"	13,500
5	628	486	385	310	253	208	173	144	121	86	60	41	27				"	14,600
6	869	674	536	432	354	293	245	206	174	125	90	65	45	30			290	16,000
7	1046	813	645	522	428	355	297	250	212	153	111	80	57	38	24		260	"
8	1223	951	755	611	501	416	348	293	248	180	131	95	67	46	29		240	"
9	1404	1091	868	702	576	478	400	338	286	208	152	111	80	55	36	20	220	"
10	1580	1229	977	792	649	539	452	381	323	235	172	126	90	63	41	23	210	"
11	1763	1370	1090	883	725	603	505	427	362	264	194	142	103	72	48	28	200	"
12"	1943	1511	1202	973	800	665	557	471	400	292	214	157	114	80	53	31	185	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 300\#/\text{sq. in.}$ $M = \frac{1}{12} w l^2$. Max. $f_s = 16{,}000\#/\text{sq. in}$

3-9-25 "Steelcrete" Expanded Metal. Area = 0.250 sq. in. per ft. of width

Slab	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"		Unit Stresses. lbs. per sq. in. Concrete	Steel
3"	215	164	127	100	79	63	51	40	32	19										300	8,400
3½	312	239	187	149	120	97	79	64	53	34	21									"	9,600
4	422	325	256	205	166	136	112	93	77	53	36	23								"	10,700
4½	544	421	333	267	218	179	149	124	104	73	51	35	22							"	11,700
5	677	525	416	336	274	227	189	158	133	95	68	48	33	21						"	12,700
6	977	760	605	490	402	334	280	237	201	147	108	79	57	40	27					"	14,500
7	1309	1021	814	661	545	454	383	324	277	205	153	115	86	63	45	31	19			"	16,000
8	1531	1194	953	775	639	533	449	381	325	241	181	136	102	75	54	37	24			275	"
9	1754	1369	1092	888	732	611	515	438	374	278	209	157	119	88	64	45	29			250	"
10	1982	1544	1234	1002	826	690	582	494	423	314	236	179	135	101	74	52	34	19		235	"
11	2207	1723	1375	1119	923	771	651	553	473	352	265	201	152	114	84	60	40	23		220	"
12"	2435	1897	1515	1233	1017	850	717	610	522	389	293	222	168	126	93	66	44	26		210	"

3-9-30 "Steelcrete" Expanded Metal Area = 0.300 sq. in. per ft. of width.

Slab	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Unit Stresses lbs. per sq. in. Concrete	Steel.
3"	226	173	134	106	85	68	54	44	35	21										300	7,400
3½	329	253	198	158	127	103	84	69	57	38	24									"	8,500
4	448	346	273	219	178	146	121	100	83	58	40	26								"	9,500
4½	576	446	353	284	232	191	159	133	112	79	56	39	26							"	10,400
5	721	560	444	359	294	243	203	171	144	104	75	54	37	25						"	11,300
6	1036	806	642	521	428	356	299	253	216	158	117	87	64	46	31	20				"	12,900
7	1405	1095	875	711	587	491	414	352	301	224	168	128	97	72	53	38	25			"	14,400
8	1808	1413	1129	921	761	637	539	459	395	296	225	172	133	102	77	57	41	27		"	15,800
9	2104	1644	1315	1072	888	744	629	537	462	347	264	204	157	121	93	70	51	35	22	280	16,000
10	2374	1855	1484	1210	1002	840	710	606	522	392	299	231	179	138	106	80	58	41	26	265	"
11	2646	2070	1657	1351	1119	938	794	678	583	439	336	259	201	156	120	91	67	47	31	245	"
12"	2920	2283	1828	1490	1234	1034	876	748	644	485	371	286	222	172	133	101	75	53	35	235	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. $f_c = 300$ #/sq. in. $M = \frac{1}{12} w l^2$. Max. $f_s = 16{,}000$ #/sq. in.

3-9-35 "Steelcrete" Expanded Metal. Area = 0.350 sq. in. per ft. of width																Unit Stresses lbs. per sq. in.	
Slab.	Span.																
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel.
3"	235	180	140	111	88	71	57	46	37	23										300	6,700
3½	343	264	207	166	134	109	89	73	60	41	26									"	7,600
4	468	361	285	229	187	153	127	106	88	62	43	29								"	8,600
4½	606	470	372	300	246	203	169	142	119	85	61	43	29							"	9,400
5	756	588	467	377	309	257	215	181	153	111	81	58	41	28						"	10,300
6	1092	851	678	551	454	378	318	269	230	169	126	94	70	51	36	24				"	11,700
7	1473	1151	919	748	618	517	436	371	318	237	180	137	104	79	59	43	29			"	13,000
8	1907	1490	1193	972	805	674	571	487	419	315	240	185	143	111	85	64	47	33	21	"	14,300
9	2374	1858	1489	1215	1008	846	718	614	529	400	308	239	187	147	115	89	68	50	36	"	15,500
10	2762	2164	1733	1415	1174	986	837	717	618	468	361	282	221	174	137	107	83	62	45	290	16,000
11	3083	2414	1935	1580	1311	1101	935	801	691	525	405	316	249	197	155	122	94	71	52	270	"
12"	3400	2660	2135	1744	1446	1215	1032	884	764	579	447	350	275	218	172	135	105	80	59	255	"

3-6-40 "Steelcrete" Expanded Metal Area = 0.400 sq. in. per ft. of width																			Unit Stresses lbs. per sq. in.	
Slab.	Span.																			
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel.
3"	244	186	145	115	92	74	60	49	39	25										300	6,100
3½	355	273	215	171	139	113	93	77	63	43	28									"	7,000
4	484	374	296	238	194	160	132	110	92	65	46	31	20							"	7,800
4½	628	487	387	312	256	211	176	148	125	90	64	46	32	21						"	8,600
5	787	612	486	394	323	268	225	190	161	117	86	62	45	31	20					"	9,400
6	1138	887	708	574	474	395	332	282	241	178	133	100	75	55	40	27				"	10,800
7	1541	1203	961	783	648	542	458	390	335	251	190	146	112	85	64	47	33	22		"	12,000
8	1988	1555	1245	1016	841	705	597	511	440	331	254	196	153	119	92	70	52	37	25	"	13,200
9	2479	1942	1556	1270	1054	886	752	644	556	421	325	253	199	157	123	96	74	56	41	"	14,300
10	3019	2364	1897	1551	1287	1083	921	790	683	519	402	316	250	199	158	125	99	76	58	"	15,400
11	3510	2753	2210	1808	1501	1264	1075	923	799	609	473	373	297	237	190	152	121	95	73	295	16,000
12"	3870	3035	2435	1995	1657	1395	1187	1018	881	673	523	412	328	262	210	169	134	106	82	280	"

"Steelcrete" MESH SLAB TABLES

Giving safe live loads in lbs. per sq. ft.

Max. f_c = 300 #/sq. in. $M = \frac{1}{12} w l^2$. Max. f_s = 16,000 #/sq. in.

3-6-45 "Steelcrete" Expanded Metal Area = 0.450 sq. in. per ft of width

Slab	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Unit Stresses lbs. per sq. in. Concrete	Steel
3"	251	192	150	119	95	77	62	51	41	26										300	5,600
3½	366	282	222	177	144	117	97	80	66	45	30	19								"	6,400
4	500	386	306	246	201	165	138	115	96	69	48	33	22							"	7,200
4½	649	503	400	323	264	219	183	154	130	94	68	49	34	22						"	8,000
5	812	632	503	407	335	278	233	197	167	122	90	66	48	33	22					"	8,700
6	1182	922	736	598	493	412	347	295	252	187	140	106	80	59	43	30	20			"	10,000
7	1604	1253	1003	817	676	566	479	408	351	263	201	154	119	91	69	52	37	26		"	11,200
8	2065	1616	1294	1056	875	735	623	532	459	347	266	206	161	126	98	75	57	42	29	"	12,200
9	2579	2019	1619	1324	1099	923	784	672	580	440	340	266	210	166	132	103	80	62	46	"	13,300
10	3139	2459	1974	1614	1342	1129	959	824	713	543	422	332	264	210	168	134	106	83	64	"	14,300
11	3735	2930	2355	1925	1601	1350	1149	988	855	654	509	403	322	259	209	168	135	108	85	"	15,200
12"	4345	3405	2738	2245	1867	1575	1340	1154	1000	766	599	475	380	307	249	202	164	132	105	"	16,000

3-6-50 "Steelcrete" Expanded Metal. Area = 0.500 sq. in. per ft. of width

Slab	Span 4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Unit Stresses lbs. per sq. in. Concrete	Steel
4"	513	397	315	253	207	171	142	119	100	71	50	35	23							300	6,700
4½	667	518	411	332	272	226	189	159	134	97	71	51	36	24						"	7,400
5	834	650	517	419	344	286	240	203	173	126	93	69	50	36	24					"	8,100
6	1216	949	758	616	508	425	358	305	261	194	146	111	84	63	46	33	22			"	9,300
7	1653	1291	1033	843	697	584	494	422	363	273	208	160	124	96	73	55	40	28		"	10,400
8	2143	1678	1344	1097	910	763	648	555	478	362	278	217	170	133	104	81	62	46	33	"	11,500
9	2674	2094	1679	1374	1140	959	815	698	604	459	355	279	220	175	139	110	86	67	50	"	12,500
10	3244	2544	2044	1671	1389	1169	995	854	740	564	438	346	275	220	177	142	113	89	69	"	13,400
11	3865	3035	2435	1995	1660	1398	1192	1025	888	679	531	420	336	271	219	177	143	115	91	"	14,300
12"	4535	3560	2860	2345	1952	1645	1403	1207	1047	803	629	500	401	325	265	216	176	142	115	"	15,100

"Steelcrete" MESH SLAB TABLES

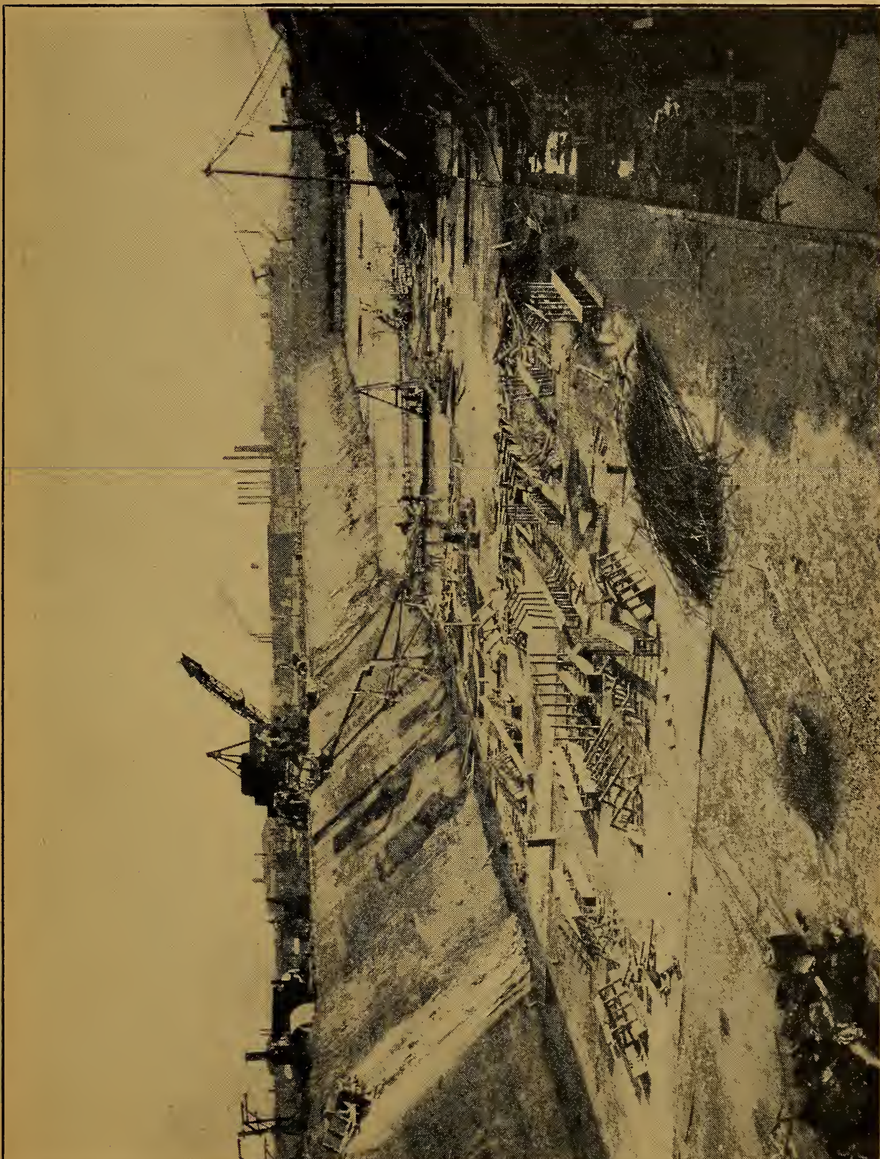
Giving safe live loads in lbs. per sq. ft.

$M = \frac{1}{12} w l^2$

Max. $f_c = 300$ #/sq. in. Max. $f_s = 16{,}000$ #/sq. in

3-6-55 "Steelcrete" Expanded Metal. Area = 0.550 sq. in. per ft. of width																				Unit Stresses lbs. per sq. in.	
Slab.	Span.																				
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel
4"	450	347	274	220	179	147	121	101	84	57	40	26								300	5,900
4½	599	464	368	297	242	200	167	140	117	84	60	42	28							"	6,600
5	765	594	472	382	313	260	217	183	155	113	82	59	42	29						"	7,300
6	1143	892	711	578	476	397	334	284	242	179	134	101	75	56	40	27				"	8,400
7	1584	1238	989	807	667	559	473	403	346	259	197	151	117	89	68	50	36	24		"	9,500
8	2073	1623	1299	1061	879	738	625	535	461	348	267	207	162	127	99	76	57	42	29	"	10,600
9	2609	2044	1639	1339	1112	935	794	681	588	446	345	270	213	169	134	106	82	63	47	"	11,500
10	3194	2504	2011	1644	1367	1150	979	840	728	554	430	339	270	216	173	138	110	86	67	"	12,400
11	3815	2993	2405	1968	1638	1380	1175	1010	875	669	522	413	331	266	215	174	140	112	89	"	13,200
12"	4505	3535	2840	2327	1937	1635	1393	1198	1040	797	624	496	398	322	262	213	174	141	113	"	14,000

3-6-60 "Steelcrete" Expanded Metal Area = 0.600 sq. in. per ft. of width.																				Unit Stresses lbs. per sq. in.	
Slab.	Span.																				
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	17'-0"	18'-0"	Concrete	Steel
4"	459	354	280	225	183	150	124	103	86	60	41	28								300	5,600
4½	612	475	376	304	248	205	171	143	121	86	62	44	30	19						"	6,200
5	780	607	482	390	320	266	223	188	159	116	85	62	44	30	20					"	6,800
6	1171	913	728	592	488	408	344	292	249	185	139	105	79	58	42	29	19			"	8,000
7	1622	1266	1013	826	683	573	485	413	355	266	203	156	121	93	71	53	39	27		"	9,000
8	2128	1665	1334	1089	903	759	643	551	475	359	276	215	168	132	103	80	61	45	32	"	10,000
9	2684	2103	1686	1379	1144	963	819	702	606	461	357	280	222	176	140	111	87	67	51	"	10,900
10	3284	2576	2069	1693	1407	1184	1008	866	749	572	445	351	280	224	180	144	115	91	71	"	11,700
11	3935	3085	2480	2032	1690	1425	1213	1044	905	693	541	429	344	277	225	182	147	119	94	"	12,500
12"	4620	3625	2915	2387	1987	1677	1430	1231	1068	820	642	511	411	333	271	222	181	147	119	"	13,300



The largest pit in the world used to submerge coal for storage, size 150 x 800 ft. in plan and 25 ft. 6 in. deep with 45 deg. side slopes, was built in 1916 by the Duquesne Light Co. of Pittsburgh. 5 carloads of expanded metal were used for reinforcing. Construction details of same were published in the Engineering Record, February 3, 1917

Introduction to Beam and Girder Tables

THE following tables have been carefully prepared for use in connection with ordinary beam and girder design. These tables have been computed on the theory of design adopted by the Joint Committee and embodied elsewhere in this book. They are divided into two groups, the one being designed for simple beams with a bending moment equal to $\frac{1}{8}$ W L and the other for continuous beams with a bending moment equal to $\frac{1}{10}$ W L. A better design may thus be obtained by properly proportioning every beam, as well as by a closer adherence to the principles involving the shear than is attainable in a single set of tables with modifying factors for the other bending moment. Unlike the case of the slab tables, the safe loads herein given include the total of the dead and live load combined. On account of the fact that the spacing of the beams, the character and composition of the floor is unknown, a safe live load table cannot be computed that would be of any practical value. In the case of the slab tables before given, the thickness of the concrete is known and, therefore, the safe live load can be given.

The minimum thickness of slab required with a given beam is given in the tables by large open number for all values within adjoining heavy lines. When the value given is O, the beam in question is sufficiently strong in compression as a rectangular beam. The compression in the stem of the beam has been in every case taken into account. It should be borne in mind that the tables are for strictly T-beam construction, commonly used in reinforced concrete.

The loads given are assumed as uniformly distributed. Cases will occur continually when the loads are more or less concentrated as is the case in girders. In order to take full advantage of the total load beam tables, it will be necessary to transfer these partially concentrated loads into equivalent uniform loads which will give equivalent results. This may be readily done by a designer under the principles governing common beam design. Having found this equivalent uniform load, it is merely necessary to enter the tables and proceed as before.

It is desirable to point out the limitations in the use of the T-beam tables given. No provision will be found for continuity over the support. The required amount of steel over the support is invariably given in specifications. In the absence of specifications, a value equal to $\frac{1}{4}$ the steel required in the center of the span should be used.

No provision for shear bars or stirrups will be found noted. The principles of shear design as recommended by the Joint Committee should be studied. In general shear reinforcement will not be required in the middle third of the beams. The tension bars at the center of the support will provide for the greater portion of the shear if bent at an angle of 45° and used as the top reinforcement over the support. One bar should be bent at the ⅓ point of span and the balance between this point and the support. Vertical stirrups of about $\frac{5}{16}''\phi$ will be invariably found necessary. The spacing is sometimes varied but in general a uniform distance of 6 inches between vertical stirrups will be usually found sufficient.

It will be noted at once that no particular order has been followed in the tables regarding the sectional areas of steel required. The compiled data has been taken from the engineering files of this company. It was at one time published. The great assistance offered by the use of these tables and the numerous requests we have had for old copies of our publication have made it advisable to offer them in their present form. We believe that they are unique in the reinforced concrete world and that after study, they will be found of great value.

The following table will be found of assistance by way of index:

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = $1\frac{1}{2}$ sq. in.

Span in Feet	Width b inches.	Total Depth in inches (D). 8	10	12	14	16	18	20	22	24	26	28
6	$13\frac{1}{2}$"		18.3	22.9								
7	"	11.6	15.6	19.6	23.6							
8	"	10.1	13.7	17.2	20.7	24.2						
9	$9\frac{3}{4}$"		12.1	15.2	18.4	21.5	24.6					
10	"		10.9	13.7	16.5	19.3	22.1	24.9				
11	$7\frac{3}{4}$"		9.9	12.5	15.0	17.6	20.1	22.6	25.2	27.7		
12	"		9.1	11.4	13.8	16.1	18.4	20.7	23.1	25.4		
13	"			10.5	12.7	14.9	17.0	19.2	21.3	23.5	25.6	
14	"			9.8	11.8	13.8	15.8	17.8	19.8	21.8	23.8	25.8
15	"			9.1	11.0	12.9	14.8	16.6	18.5	20.4	22.2	24.1
16	"			8.6	10.3	12.1	13.8	15.6	17.3	19.1	20.8	22.6
17	"				9.7	11.4	13.0	14.7	16.3	18.0	19.5	21.2
18	"				9.2	10.7	12.3	13.9	15.4	17.0	18.5	20.1
19	"				8.7	10.2	11.6	13.1	14.6	16.1	17.5	19.1
20	"					9.7	11.1	12.5	13.9	15.3	16.6	18.1
21	"					9.2	10.6	11.9	13.2	14.5	15.8	17.2
22	"						10.1	11.3	12.6	13.9	15.1	16.4
23	"						9.6	10.8	12.1	13.3	14.4	15.7
24	"						9.2	10.4	11.6	12.8	13.8	15.0

0

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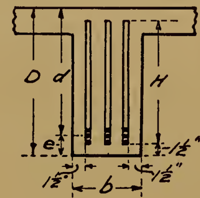


Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.
" " " support = 100 bjd.

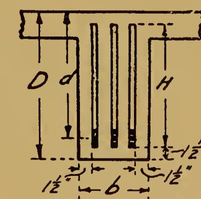
Stress in concrete = 750 #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = $2\frac{1}{4}$ sq. in.

Span in Feet	Width b inches	Total Depth in inches (D). 10	12	14	16	18	20	22	24	26	28
8	$15\frac{1}{2}$	20.3	25.5	30.8	36.0						
9	"	18.0	22.6	27.4	32.0	36.7					
10	"	16.2	20.4	24.6	28.8	33.0	37.2				
11	$11\frac{3}{4}$	14.7	18.5	22.4	26.2	30.0	33.8	37.7	41.5		
12	"	13.5	17.0	20.5	24.0	27.5	31.0	34.5	38.0		
13	"		15.7	18.9	22.1	25.4	28.6	31.9	35.1	38.3	
14	$8\frac{3}{4}$"		14.6	17.6	20.6	23.6	26.6	29.6	32.6	35.6	38.6
15	"		13.6	16.4	19.2	22.0	24.8	27.6	30.4	33.2	36.0
16	"		12.7	15.4	18.0	20.6	23.3	25.9	28.5	31.1	33.7
17	"			14.5	16.9	19.4	21.9	24.4	26.8	29.3	31.8
18	"			13.7	16.0	18.3	20.7	23.0	25.3	27.7	30.0
19	"			13.0	15.1	17.3	19.6	21.8	24.0	26.2	28.4
20	"				14.4	16.5	18.6	20.7	22.8	24.9	27.0
22	"				13.1	15.0	16.9	18.8	20.8	22.6	24.6
24	"					13.7	15.5	17.3	19.0	20.8	22.5
26	"						14.3	16.0	17.5	19.2	20.8
28	"							14.8	16.3	17.8	19.3



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $\quad M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = $50bjd$.

" " " support = $100bjd$.

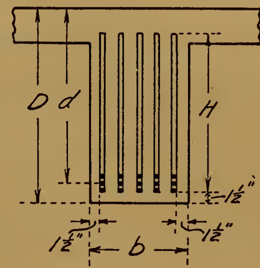
Stress in concrete = 750 #/sq. in.

Note:– Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = $2\frac{1}{2}$ sq. in.

Span in Feet.	Width b inches.	Total depth in inches (D). 10	12	14	16	18	20	22	24	26	28.
9	$11\frac{3}{4}$	20.2	25.5	30.6							
10	"	18.2	22.9	27.6	32.2						
11	"	16.5	20.8	25.1	29.3	33.6					
12	"	15.1	19.1	23.0	26.8	30.7	34.6				
13	"		17.6	21.2	24.8	28.4	32.0	35.6	39.2		
14	"		16.4	19.7	23.0	26.4	29.7	33.1	36.4	39.7	
15	"		15.3	18.4	21.5	24.6	27.7	30.8	33.9	37.1	
16	"		14.3	17.2	20.1	23.1	25.9	28.9	31.8	34.7	37.7
17	"			16.2	18.9	21.7	24.5	27.2	29.9	32.7	35.5
18	"			15.3	17.9	20.5	23.1	25.7	28.3	30.9	33.5
19	"			14.5	16.9	19.4	21.9	24.3	26.8	29.3	31.7
20	"				16.1	18.4	20.8	23.1	25.5	27.8	30.1
21	"				15.3	17.6	19.8	22.1	24.3	26.5	28.7
22	"					16.8	18.9	21.0	23.1	25.3	27.4
23	"					16.1	18.1	20.1	22.1	24.2	26.2
24	"					15.4	17.3	19.3	21.2	23.2	25.1



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.
" " " support = 150 bjd.

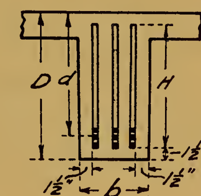
Stress in concrete = 750 #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = 3 sq. in.

Span in Feet	Width b inches	Total depth in inches (D). 12	14	16	18	20	22	24	26	28	30	32	34	36
12	$13\frac{1}{2}$	22.2	26.9	31.6	36.2	40.9	45.5	50.2						
13	"	20.5	24.8	29.1	33.4	37.8	42.0	46.4	50.8					
14	$11\frac{3}{4}$	19.1	23.0	27.1	31.0	35.1	39.0	43.1	47.2	51.1	55.1			
15	"	17.8	21.5	25.3	29.0	32.7	36.4	40.2	44.0	47.7	51.4	55.1		
16	"	16.7	20.2	23.7	27.2	30.7	34.2	37.7	41.2	44.7	48.2	51.7	55.2	58.7
17	$9\frac{3}{4}$		18.9	22.3	25.6	28.9	32.1	35.4	38.8	42.1	45.4	48.7	51.9	55.2
18	"		17.9	21.1	24.2	27.3	30.3	33.5	36.7	39.7	42.8	46.0	49.1	52.2
19	$8\frac{3}{4}$		16.9	19.9	22.9	25.8	28.7	31.7	34.7	37.7	40.6	43.6	46.5	49.4
20	"			18.9	21.7	24.6	27.3	30.1	33.0	35.7	38.5	41.4	44.2	46.9
21	"			18.1	20.7	23.4	26.0	28.7	31.4	34.1	36.7	39.4	42.1	44.7
22	"			17.2	19.7	22.3	24.8	27.4	30.0	32.5	35.1	37.6	40.2	42.7
24	"				18.1	20.5	22.8	25.1	27.5	29.8	32.1	34.5	36.8	39.1
26	"					18.9	21.0	23.2	25.4	27.5	29.7	31.9	34.0	36.1
28	"						19.5	21.5	23.6	25.5	27.6	29.6	31.6	33.5
30	"							20.1	22.0	23.9	25.7	27.6	29.5	31.3
32	"								20.6	22.4	24.1	25.9	27.6	29.3
34	"									21.0	22.6	24.4	26.0	27.6
36	"									19.9	21.4	23.0	24.5	26.0



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd$.

$jd = \frac{7}{8}d$ = effective depth

Max. shear at first riser = 50 bjd.
" " " support = 100 bjd.

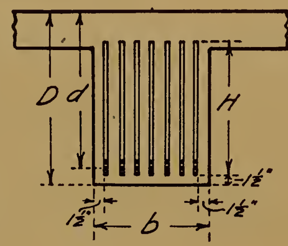
Stress in concrete = 750 #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams — Steel Area = $3\frac{1}{2}$ sq. in.

Span in Feet.	Width b inches	Total depth in inches (D). 10	12	14	16	18	20	22	24	26	28.
10	$15\frac{1}{2}$		32.1	38.6	45.1						
11	"		29.1	35.1	41.0						
12	"	21.3	26.7	32.1	37.6	43.0	48.6				
13	"	19.6	24.6	29.7	34.7	39.7	44.8	49.8			
14	"	18.2	22.9	27.6	32.2	36.9	41.6	46.2	50.9		
15	"		21.4	25.7	30.1	34.5	38.8	43.1	47.5	51.8	
16	"		20.1	24.1	28.2	32.3	36.4	40.5	44.6	48.6	52.6
17	"			22.7	26.5	30.4	34.3	38.1	41.9	45.8	49.6
18	"			21.4	25.1	28.7	32.4	35.9	39.6	43.2	46.8
19	"			20.3	23.7	27.2	30.7	34.1	37.5	40.9	44.3
20	"				22.5	25.8	29.1	32.3	35.7	38.9	42.1
21	"				21.5	24.6	27.7	30.8	33.9	37.0	40.1
22	"					23.5	26.5	29.4	32.4	35.3	38.3
23	"					22.5	25.3	28.1	31.0	33.8	36.6
24	"					21.5	24.3	27.0	29.7	32.4	35.1



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 150 bjd.

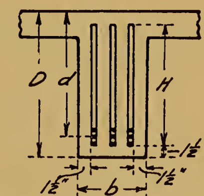
Stress in concrete = 750 #/sq. in.

Note:— Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = $3\frac{3}{4}$ sq. in.

Span in Feet	Width b inches	Total depth in inches (D). 14	16	18	20	22	24	26	28	30	32	34	36.
13	$15\frac{1}{2}$	30.7	36.1	41.4	46.8	52.2	57.6	63.1	68.4	73.8		0	
14	"	28.5	33.5	38.5	43.5	48.4	53.5	58.6	63.5	68.5	73.6		
15	$13\frac{1}{2}$	26.6	31.3	35.9	40.6	45.2	49.9	54.6	59.3	63.9	68.6	73.3	77.9
16	"	24.9	29.3	33.7	38.1	42.4	46.8	51.2	55.6	59.9	64.3	68.7	73.1
17	$11\frac{3}{4}$	23.5	27.6	31.7	35.8	39.9	44.1	48.2	52.3	56.4	60.5	64.7	68.7
18	"	22.1	26.1	29.9	33.9	37.7	41.6	45.6	49.4	53.3	57.1	61.1	64.9
19	"	21.0	24.7	28.4	32.1	35.7	39.4	43.1	46.8	50.5	54.1	57.8	61.5
20	"		23.4	26.9	30.4	33.9	37.4	40.9	44.4	47.9	51.4	54.9	58.4
21	$9\frac{3}{4}$		22.3	25.7	29.0	32.3	35.7	39.0	42.3	45.7	49.0	52.3	55.6
22	"		21.3	24.5	27.7	30.8	34.1	37.3	40.4	43.6	46.8	50.0	53.1
23	"	4	20.4	23.5	26.5	29.5	32.6	35.7	38.7	41.7	44.8	47.8	50.8
24	"			22.5	25.4	28.3	31.2	34.2	37.1	39.9	42.8	45.8	48.7
25	"			21.6	24.4	27.1	29.9	32.8	35.6	38.4	41.1	43.9	46.7
26	"				23.5	26.1	28.8	31.5	34.2	36.9	39.5	42.3	44.9
28	"					24.2	26.7	29.3	31.7	34.3	36.8	39.3	41.8
30	"						25.0	27.3	29.7	32.0	34.3	36.7	38.9
32	"						23.4	25.6	27.8	30.0	32.2	34.3	36.5
34	"							24.1	26.1	28.2	30.3	32.3	34.4
36	"								24.7	26.7	28.6	30.5	32.5



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\ Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.
" " " support = 100 bjd.

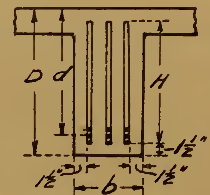
Stress in concrete = 750 #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area $= 4\frac{1}{2}$ sq. in.

Span in Feet	Width b inches	16	18	20	22	24	26	28	30	32	34	36
		Total depth in inches (D).										
15	$17\frac{1}{2}$	37.2	42.7	48.4	53.9	59.5	65.1	70.7	76.3	81.9		
16	$15\frac{1}{2}$	34.8	40.1	45.4	50.5	55.8	61.0	66.4	71.5	76.8	82.1	87.3
17	"	32.8	37.7	42.8	47.6	52.6	57.4	62.4	67.4	72.4	77.3	82.1
18	$13\frac{1}{2}$	30.9	35.6	40.4	44.9	49.6	54.2	58.9	63.5	68.3	72.9	77.5
19	"	29.3	33.8	38.3	42.6	47.0	51.4	55.9	60.2	64.8	69.1	73.5
20	"	27.9	32.1	36.3	40.4	44.7	48.8	53.1	57.2	61.5	65.7	69.7
21	$11\frac{3}{4}$	26.5	30.6	34.6	38.5	42.6	46.5	50.6	54.5	58.5	62.5	66.5
22	"	25.3	29.2	33.1	36.8	40.6	44.4	48.2	52.0	55.9	59.7	63.5
23	"		27.9	31.6	35.2	38.8	42.4	46.1	49.8	53.4	57.1	60.6
24	"		26.8	30.3	33.7	37.2	40.7	44.2	47.6	51.2	54.7	58.2
25	$9\frac{3}{4}$			29.1	32.4	35.7	39.1	42.4	45.8	49.2	52.5	55.8
26	"			28.0	31.1	34.4	37.6	40.8	44.0	47.4	50.4	53.6
27	"				30.0	33.1	36.2	39.3	42.4	45.5	48.6	51.7
28	"					31.9	34.9	37.9	40.8	43.9	46.9	49.8
29	"					30.8	33.7	36.6	39.5	42.4	45.3	48.2
30	"					29.8	32.5	35.4	38.1	40.9	43.7	46.6
32	"						30.5	33.2	35.7	38.4	41.1	43.6
34	"						28.7	31.2	33.7	36.2	38.6	41.1
36	"							29.5	31.8	34.1	36.5	38.7



Stress in steel $= 16{,}000$ #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd$

$jd = \frac{7}{8}d =$ effective depth.

Max. shear at first riser $= 50bjd$

" " " support $= 100bjd$.

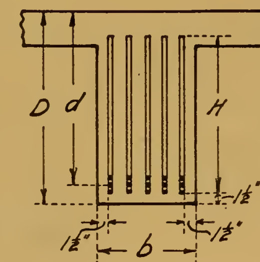
Stress in concrete $= 750$ #/sq. in.

Note:— Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = 5 sq. in.

Span in Feet.	Width b inches	Total depth in inches (D). 12	14	16	18	20	22	24	26	28	30	32	34	36
13	$15\frac{1}{2}$		41.4	48.6	55.7	62.9	70.1	77.4						
14	$13\frac{1}{2}$	31.8	38.4	45.1	51.8	58.4	65.1	71.8	78.5					
15	"	29.6	35.9	42.1	48.3	54.6	60.7	67.0	73.3					
16	"	27.8	33.7	39.5	45.3	51.1	56.9	62.9	68.6	74.5	80.2			
17	"		31.7	37.1	42.6	48.1	53.6	59.1	64.6	70.2	75.5	81.1		
18	"		29.9	35.1	40.3	45.5	50.6	55.8	61.0	66.3	71.4	76.7	81.8	
19	"		28.3	33.2	38.1	43.1	47.9	52.9	57.8	62.8	67.6	72.6	77.4	82.4
20	"			31.6	36.2	40.9	45.6	50.2	54.9	59.6	64.2	68.9	73.6	78.2
21	"			30.1	34.5	38.9	43.4	47.9	52.4	56.8	61.1	65.6	70.1	74.6
22	"			28.7	32.9	37.2	41.4	45.6	49.9	54.2	58.4	62.7	66.9	71.2
24	"				30.2	34.1	37.9	41.9	45.8	49.7	53.5	57.4	61.4	65.3
26	"					31.5	35.1	38.7	42.3	45.8	49.4	53.0	56.6	60.2
28	"						32.5	35.9	39.3	42.6	45.8	49.2	52.6	55.9
30	"							33.5	36.6	39.7	42.8	45.9	49.1	52.2
32	"								34.3	37.3	40.2	43.1	46.0	48.9
34	"									35.1	37.7	40.6	43.3	46.0
36	"									33.1	35.7	38.3	40.8	43.4



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 150 bjd.

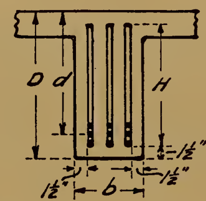
Stress in concrete = 750 #/sq. in.

Note:–
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area $= 5\frac{1}{4}$ sq. in.

Span in Feet	Width b inches	Total depth in inches (D). 18	20	22	24	26	28	30	32	34	36	38	40
15	$19\frac{1}{2}$	49.8	56.3	62.8	69.4	75.9	82.4	89.0	95.5				
16	$17\frac{1}{2}$	46.7	52.8	58.9	65.1	71.2	77.3	83.4	89.6	95.7	101.8		
17	"	43.9	49.7	55.4	61.2	67.0	72.8	78.5	84.3	90.1	95.8	101.6	
18	"	41.5	46.9	52.4	57.8	63.2	68.7	74.2	79.6	85.1	90.4	96.0	101.2
19	$15\frac{1}{2}$	39.3	44.5	49.6	54.7	59.9	65.2	70.4	75.5	80.6	85.7	90.8	95.9
20	"	37.4	42.3	47.1	52.0	56.9	61.9	66.9	71.7	76.6	81.4	86.4	91.2
21	$13\frac{1}{2}$	35.6	40.3	44.9	49.5	54.2	58.9	63.7	68.3	72.9	77.5	82.2	86.8
22	"	33.9	38.4	42.8	47.3	51.7	56.3	60.8	65.2	69.6	74.0	78.5	82.9
23	"	32.5	36.8	40.9	45.2	49.5	53.8	58.1	62.4	66.6	70.8	75.1	79.3
24	$11\frac{3}{4}$		35.2	39.3	43.3	47.4	51.6	55.6	59.8	63.8	67.8	71.9	76.0
25	"		33.9	37.7	41.6	45.5	49.4	53.4	57.3	61.3	65.1	69.1	72.9
26	"		32.5	36.2	40.0	43.8	47.6	51.4	55.2	58.9	62.6	66.4	70.2
27	"			34.9	38.5	42.1	45.8	49.5	53.1	56.7	60.4	64.0	67.5
28	"			33.6	37.1	40.6	44.2	47.7	51.2	54.6	58.1	61.6	65.2
29	"				35.9	39.3	42.6	46.1	49.4	52.8	56.1	59.6	62.8
30	"				34.7	37.9	41.2	44.6	47.8	51.1	54.2	57.6	60.8
32	"					35.5	38.7	41.8	44.8	47.8	50.8	53.9	57.0
34	"					33.5	36.4	39.3	42.2	45.0	47.8	50.7	53.6
36	"						34.3	37.1	39.8	42.5	45.2	47.9	50.7



Stress in steel $= 16{,}000$ #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd$.

$jd = \frac{7}{8}d =$ effective depth.

Max. shear at first riser $= 50bjd$

" " " support $= 100bjd$.

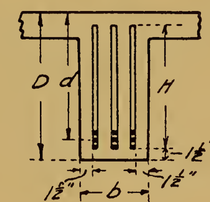
Stress in concrete $= 750$ #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = 6 sq. in.

Span in Feet	Width b inches	Total depth in inches (D). 20	22	24	26	28	30	32	34	36	38	40	42	44
17	$19\frac{1}{2}$	56.4	63.0	69.6	76.2	82.8	89.4	96.0	102.5	109.1	115.8			
18	"	53.3	59.5	65.7	72.0	78.2	84.5	90.7	96.9	103.1	109.1	115.5		
19	$17\frac{1}{2}$	50.5	56.4	62.3	68.2	74.1	80.0	85.9	91.7	97.7	103.5	109.4	115.2	
20	"	48.0	53.6	59.2	64.8	70.4	76.0	81.6	87.2	92.8	98.3	104.0	109.5	115.2
21	$15\frac{1}{2}$	45.7	51.0	56.3	61.7	67.1	72.4	77.8	83.0	88.4	93.7	98.9	104.2	109.8
22	"	43.6	48.7	53.8	58.9	64.0	69.1	74.2	79.2	84.4	89.4	94.5	99.6	104.8
23	"	41.7	46.6	51.4	56.3	61.2	66.1	70.9	75.8	80.8	85.4	90.4	95.3	100.2
24	$13\frac{1}{2}$	40.0	44.6	49.3	54.0	58.6	63.4	68.1	72.7	77.3	81.9	86.7	91.3	96.1
25	"	38.4	42.9	47.3	51.9	56.3	60.8	65.3	69.7	74.2	78.6	83.2	87.7	92.3
26	"	36.9	41.2	45.5	49.8	54.1	58.4	62.8	67.1	71.4	75.6	80.0	84.3	88.7
27	"		39.7	43.8	48.0	52.1	56.3	60.5	64.6	68.8	72.8	77.0	81.2	85.4
28	"		38.3	42.3	46.2	50.3	54.3	58.3	62.2	66.3	70.2	74.3	78.3	82.3
29	"			40.8	44.7	48.5	52.4	56.3	60.1	64.0	67.8	71.7	75.5	79.5
30	"			39.4	43.2	46.9	50.7	54.4	58.1	61.9	65.5	69.3	73.0	76.8
32	"				40.5	43.9	47.5	51.1	54.4	58.0	61.4	65.0	68.5	72.1
34	"				38.1	41.4	44.6	48.0	51.2	54.6	57.7	61.1	64.4	67.8
36	"					39.1	42.2	45.3	48.4	51.6	54.6	57.7	60.8	64.1
38	"					37.1	40.0	42.9	45.8	48.8	51.7	54.7	57.7	60.6
40	"						38.0	40.8	43.6	46.4	49.1	51.9	54.8	57.6



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.
" " " support = 100 bjd.

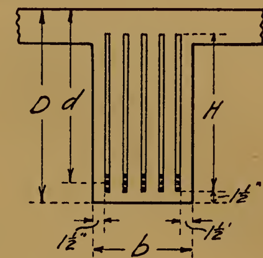
Stress in concrete = 750 #/sq. in.

Note:— Minimum thickness of slab for values within adjoining heavy lines given by large open numbers

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = $6\frac{1}{4}$ sq. in.

Span in Feet	Width b inches	14	16	18	20	22	24	26	28	30	32	34	36
		Total depth in inches (D).											
13	18½		60.2	69.1	78.0	87.2	96.1						
14	"		55.8	64.2	72.4	80.9	89.3	97.5					
15	15½	44.3	52.1	59.9	67.8	75.4	83.3	91.0	98.8	106.6			
16	"	41.5	48.9	56.1	63.4	70.7	78.0	85.3	92.6	99.8	107.1	114.5	
17	13½	39.1	46.0	52.8	59.7	66.6	73.4	80.2	87.1	94.0	100.9	107.8	114.7
18	"	36.9	43.4	49.9	56.3	62.9	69.4	75.8	82.3	88.8	95.4	101.8	108.1
19	"	35.0	41.1	47.3	53.4	59.6	65.8	71.8	77.9	84.1	90.3	96.4	102.7
20	"		39.1	44.9	50.7	56.6	62.4	68.2	74.1	79.9	85.8	91.6	97.4
21	"	6	37.3	42.8	48.3	53.9	59.4	65.0	70.6	76.1	81.7	87.2	92.8
22	"		35.5	40.8	46.1	51.4	56.8	62.0	67.4	72.7	77.9	83.3	88.6
23	"		34.0	39.1	44.1	49.3	54.3	59.4	64.4	69.5	74.6	79.6	84.7
24	"			37.5	42.3	47.2	52.1	56.9	61.7	66.6	71.5	76.3	81.2
25	"			35.9	40.6	45.3	49.9	54.6	59.3	63.9	68.6	73.2	77.9
26	"				39.0	43.6	48.0	52.4	57.0	61.5	65.9	70.4	74.9
28	"		5			40.4	44.6	48.8	52.9	57.2	61.3	65.5	69.6
30	"						41.6	45.5	49.4	53.3	57.2	61.1	64.9
32	"						39.0	42.6	46.3	50.0	53.6	57.2	60.9
34	"							40.1	43.6	47.0	50.4	53.8	57.2
36	"								41.1	44.4	47.6	50.8	54.1



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = $50bjd.$

" " " support = $150bjd.$

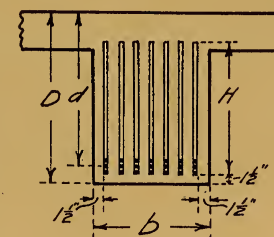
Stress in concrete = 750 #/sq. in.

Note:— Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = 7 sq. in.

Span in Feet.	Width b inches	Total depth in inches (D). 14	16	18	20	22	24	26	28	30	32	34	36.
13	19½			78.0	88.1								
14	"		63.2	72.4	81.8	91.2	100.4						
15	"		59.0	67.6	76.3	85.0	93.8						
16	16½	47.1	55.3	63.4	71.6	79.8	87.9	96.1					
17	"	44.3	52.1	59.6	67.4	75.0	82.7	90.4	98.1	105.8			
18	"	41.8	49.2	56.3	63.6	70.9	78.1	85.4	92.7	99.9	107.2		
19	"	39.6	46.6	53.4	60.3	67.1	74.0	80.9	87.8	94.7	101.6		
20	"		44.2	50.7	57.3	63.8	70.3	76.9	83.4	89.9	96.4	103.0	109.5
21	"		42.1	48.2	54.6	60.7	66.9	73.2	79.4	85.7	91.8	98.1	104.3
22	"		40.2	46.1	52.1	58.0	63.9	69.9	75.8	81.8	87.7	93.7	99.5
24	"			42.2	47.7	53.2	58.6	64.1	69.5	74.9	80.4	85.9	91.3
26	"				44.1	49.1	54.1	59.1	64.2	69.2	74.2	79.2	84.2
28	"					45.6	50.2	54.9	59.6	64.2	68.9	73.6	78.2
30	"						46.9	51.3	55.6	59.9	64.4	68.7	73.0
32	"							48.1	52.2	56.2	60.3	64.4	68.5
34	"								49.1	52.9	56.7	60.6	64.4
36	"								46.4	50.0	53.6	57.2	60.9



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth

Max. shear at first riser = 50 bjd

" " " support = 150 bjd.

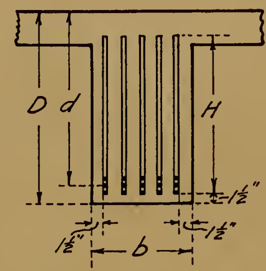
Stress in concrete = 750 #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = $7\frac{1}{2}$ sq. in.

Span in Feet.	Width b inches	Total depth in inches (D). 16	18	20	22	24	26	28	30	32	34	36	38	40
15	$21\frac{1}{2}$	61.9	71.2	80.5	89.8	99.2	108.5							
16	$17\frac{1}{2}$	58.0	66.8	75.5	84.3	93.0	101.8	110.4	119.2					
17	"	54.6	62.8	71.1	79.3	87.6	95.8	104.0	112.2	120.5				
18	$15\frac{1}{2}$	51.5	59.4	67.1	74.9	82.7	90.4	98.3	105.9	113.8	121.5	129.3		
19	"	48.9	56.3	63.6	71.0	78.4	85.7	93.1	100.3	107.8	115.2	122.5	130.0	
20	$13\frac{1}{2}$	46.4	53.4	60.4	67.4	74.4	81.4	88.4	95.4	102.4	109.4	116.4	123.4	
21	"	44.2	50.9	57.5	64.2	70.9	77.6	84.2	90.9	97.6	104.2	110.9	117.6	124.2
22	"	42.2	48.5	54.9	61.3	67.7	74.1	80.4	86.8	93.2	99.6	105.9	112.1	118.5
23	"		46.4	52.5	58.6	64.7	70.8	76.9	83.0	89.1	95.2	101.2	107.2	113.5
24	"		44.5	50.3	56.2	62.0	67.9	73.7	79.6	85.4	91.1	97.1	102.9	108.6
25	"			48.3	53.9	59.5	65.1	70.7	76.4	82.0	87.6	93.2	98.7	104.5
26	"			46.4	51.9	57.2	62.6	68.0	73.4	78.9	84.2	89.6	95.0	100.4
27	"				49.9	55.1	60.4	65.5	70.7	75.9	81.1	86.2	91.5	96.7
28	"				48.2	53.1	58.2	63.2	68.2	73.2	78.2	83.2	88.2	93.2
29	"					51.3	56.2	60.9	65.8	70.7	75.5	80.4	85.2	90.0
30	"					49.6	54.3	58.9	63.6	68.4	72.9	77.7	82.3	86.9
32	"						50.9	55.2	59.7	64.0	68.4	72.8	77.2	81.5
34	"						47.8	52.0	56.1	60.2	64.3	68.5	72.6	76.7
36	"							49.1	53.0	56.9	60.8	64.6	68.6	72.4



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000 Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 150 bjd.

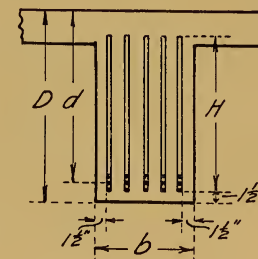
Stress in concrete = 750 #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = $8\frac{3}{4}$ sq. in.

Span in Feet	Width b inches	18	20	22	24	26	28	30	32	34	36	38	40.
		Total depth in inches (D).											
15	$21\frac{1}{2}$	82.9	93.7	104.7	115.6	126.4							
16	$19\frac{1}{2}$	77.8	87.8	98.1	108.4	118.6	128.9	139.0					
17	"	73.2	82.6	92.3	102.0	111.5	121.1	130.8	140.4				
18	$17\frac{1}{2}$	69.2	78.1	87.2	96.3	105.4	114.5	123.5	132.7	141.8	150.7		
19	"	65.5	74.1	82.6	91.3	99.8	108.3	117.0	125.6	134.2	142.8		
20	"	62.2	70.3	78.5	86.7	94.8	103.0	111.1	119.3	127.5	135.6		
21	$15\frac{1}{2}$	59.3	66.9	74.7	82.5	90.4	98.2	105.9	113.8	121.5	129.3	136.8	144.8
22	"	56.6	63.9	71.4	78.8	86.3	93.7	101.1	108.5	116.0	123.4	130.7	138.1
23	"	54.1	61.1	68.3	75.4	82.4	89.6	96.8	103.8	110.9	117.9	125.0	132.0
24	"		58.6	65.4	72.3	79.0	85.9	92.7	99.5	106.2	113.0	119.8	126.6
25	"		56.2	62.8	69.4	75.9	82.5	88.9	95.5	102.0	108.6	115.1	121.5
26	"		54.1	60.4	66.8	72.9	79.3	85.5	91.8	98.2	104.5	110.6	116.8
27	"			58.1	64.3	70.2	76.3	82.4	88.5	94.5	100.6	106.6	112.6
28	"			56.1	61.9	67.7	73.6	79.4	85.3	91.2	96.8	102.6	108.5
29	"				59.8	65.4	71.1	76.7	82.3	88.0	93.7	99.2	104.8
30	"				57.9	63.2	68.7	74.1	79.6	85.1	90.4	95.8	101.2
32	"					59.3	64.4	69.5	74.6	79.8	84.8	89.8	94.9
34	"					55.7	60.6	65.4	70.2	75.1	79.9	84.6	89.4
36	"						57.2	61.7	66.3	70.8	75.3	79.8	84.4



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd$.

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = $50bjd$.

" " " support = $150bjd$.

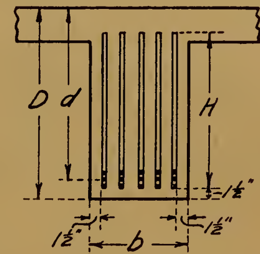
Stress in concrete = 750 #/sq. in.

Note:– Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = 10 sq. in.

Span in Feet.	Width b inches	Total depth in inches (D). 20	22	24	26	28	30	32	34	36	38	40	42	44
17	21½	94.1	105.1	116.2	127.0	138.1	148.9	159.9						
18	"	88.8	99.3	109.6	119.9	130.2	140.7	151.0	161.3	172.0				
19	"	84.1	94.0	103.8	113.7	123.5	133.2	143.1	152.8	162.6				
20	19½	79.9	89.4	98.6	108.0	117.3	126.5	135.9	145.1	154.6	164.0			
21	17½	76.2	85.1	93.8	102.8	111.8	120.6	129.4	138.2	147.4	156.2	164.9		
22	"	72.7	81.3	89.6	98.3	106.8	115.1	123.5	132.0	140.7	149.2	157.3	166.0	
23	15½	69.5	77.7	85.7	93.9	102.0	110.0	118.1	126.2	134.5	142.5	150.6	158.8	167.0
24	"	66.6	74.4	82.2	90.0	97.8	105.4	113.2	121.0	129.0	136.6	144.2	152.2	160.0
25	"	63.9	71.5	78.8	86.4	93.9	101.2	108.8	116.1	123.7	131.1	138.5	146.1	153.6
26	"	61.5	68.7	75.8	83.1	90.3	97.4	104.5	111.7	119.1	126.1	133.2	140.5	147.7
27	"		66.2	72.9	79.9	86.9	93.7	100.6	107.5	114.7	121.5	128.3	135.3	142.3
28	"		63.8	70.4	77.1	83.8	90.4	97.1	103.8	110.4	117.1	123.8	130.4	137.1
29	"			68.1	74.4	80.9	87.3	93.7	100.1	106.8	113.1	119.4	125.9	132.4
30	"			65.7	71.9	78.3	84.4	90.6	96.8	103.2	109.2	115.5	121.8	128.0
32	"				67.4	73.4	79.2	84.9	90.8	96.8	102.4	108.3	114.2	120.0
34	"				63.5	69.0	74.4	79.8	85.4	91.1	96.5	101.9	107.4	112.9
36	"					65.2	70.3	75.6	80.6	86.0	91.1	96.3	101.4	106.7
38	"					61.8	66.6	71.5	76.4	81.4	86.4	91.3	96.2	101.1
40	"						63.3	68.0	72.6	77.4	82.0	86.6	91.4	96.0



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50bjd.

" " " support = 150bjd.

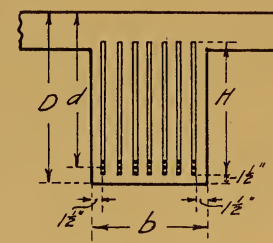
Stress in concrete = 750 #/sq. in.

Note:— Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = $10\frac{1}{2}$ sq. in.

Span in Feet	Width b inches	Total depth in inches (D). 18	20	22	24	26	28	30	32	34	36	38	40
15	25			125.9	139.0	152.0							
16	$23\frac{1}{2}$		105.8	118.1	130.3	142.5							
17	"		99.5	111.1	122.8	134.1	145.5	157.1					
18	$21\frac{1}{2}$	83.2	94.0	104.9	115.9	126.7	137.5	148.3	159.2				
19	"	78.8	89.0	99.4	109.8	120.0	130.1	140.5	151.0				
20	$19\frac{1}{2}$	74.8	84.6	94.4	104.2	114.0	123.8	133.6	143.4	153.2	163.0		
21	$18\frac{1}{2}$	71.3	80.6	89.9	99.3	108.7	117.8	127.1	136.7	145.8	155.2	164.5	
22	"	68.0	76.9	85.8	94.8	103.6	112.3	121.5	130.4	139.2	148.1	157.0	166.0
23	"	65.1	73.6	82.2	90.7	99.2	107.5	116.1	124.8	133.3	141.8	150.1	158.8
24	"	62.4	70.5	78.7	86.9	95.0	103.1	111.3	119.6	127.6	135.8	143.9	152.1
25	"		67.7	75.5	83.4	91.2	98.9	106.8	114.8	122.5	130.3	138.1	146.0
26	"		65.1	72.7	80.2	87.7	95.2	102.8	110.3	117.7	125.3	132.9	140.4
27	"			70.0	77.3	84.4	91.6	98.9	106.2	113.4	120.8	128.0	135.2
28	"			67.5	74.5	81.4	88.3	95.4	102.4	109.3	116.3	123.3	130.4
29	"				71.9	78.7	85.3	92.2	98.9	105.7	112.3	119.1	125.9
30	"				69.5	76.0	82.4	89.1	95.7	102.1	108.6	115.2	121.8
32	"					71.3	77.3	83.4	89.6	95.8	101.8	107.9	114.1
34	"					67.1	72.7	78.6	84.4	90.2	95.8	101.6	107.4
36	"						68.7	74.2	79.7	85.2	90.5	95.9	101.4



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,Ajd$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 150 bjd.

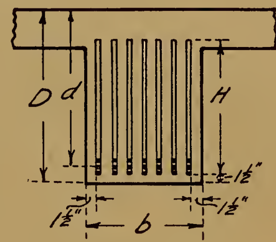
Stress in concrete = 750 #/sq. in.

Note:– Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. Steel Area = $12\frac{1}{4}$ sq. in.

Span in Feet.	Width b inches	Total depth in inches (D). 20	22	24	26	28	30	32	34	36	38	40
16	$27\frac{1}{2}$			151.6	166.0							
17	"		129.4	142.9	156.3	169.8	183.3					
18	$24\frac{1}{2}$		122.2	134.9	147.6	160.3	173.1	185.8				
19	"	103.8	115.8	127.9	139.7	151.9	163.9	176.0				
20	"	98.5	110.0	121.4	132.8	144.2	155.7	167.2	178.7	190.0		
21	$21\frac{1}{2}$	93.8	104.8	115.8	126.5	137.5	148.5	159.1	170.1	180.8	191.9	
22	"	89.6	100.0	110.3	120.9	131.1	141.8	152.0	162.4	172.7	183.2	193.5
23	$19\frac{1}{2}$	85.7	95.6	105.5	115.4	125.5	135.4	145.3	155.3	165.3	175.2	185.1
24	"	82.1	91.6	101.2	110.8	120.2	129.7	139.4	148.9	158.4	167.9	177.4
25	"	78.8	88.0	97.2	106.3	115.5	124.6	133.8	142.9	151.9	161.2	170.3
26	"	75.8	84.6	93.4	102.2	111.0	119.9	128.7	137.3	146.2	155.0	163.8
27	"		81.5	89.9	98.4	106.9	115.4	123.9	132.2	140.8	149.2	157.6
28	"		78.6	86.7	94.9	103.1	111.3	119.4	127.6	135.8	143.9	152.1
29	"			83.8	91.7	99.5	107.4	115.3	123.2	131.0	139.0	146.8
30	"			80.9	88.7	96.3	103.9	111.5	119.0	126.7	134.3	141.9
32	"				83.1	90.3	97.4	104.5	111.7	118.8	126.0	133.1
34	"				78.2	84.8	91.6	98.4	105.1	111.8	118.5	125.2
36	"					80.2	86.6	92.9	99.3	105.5	112.0	118.3



Stress in steel = 16,000 #/sq. in

$M = \frac{Wl}{8}$ $M_s = 16{,}000\,A\,jd$.

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 150 bjd.

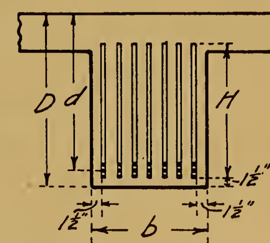
Stress in concrete = 750 #/sq. in

Note:- Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Simple Beams. **Steel Area = 14 sq. in.**

Span in Feet	Width b inches	20	22	24	26	28	30	32	34	36	38	40	42
		Total depth in inches (D).											
17	31½				177.8	193.4	208.5						
18	28½			153.5	167.9	182.5	196.9	211.4					
19	"		131.6	145.5	159.1	173.0	186.7	200.5	214.2				
20	26		125.1	138.2	151.1	164.0	177.2	190.3	203.2	216.5			
21	24	106.8	119.1	131.4	144.0	156.5	168.8	181.4	193.8	206.2	218.7		
22	"	101.8	113.8	125.6	137.3	149.5	161.1	173.0	185.1	196.8	208.9	220.9	
23	"	97.4	108.8	120.2	131.3	143.0	154.0	165.5	177.0	188.1	199.7	211.0	
24	21½	93.4	104.2	115.1	126.0	137.0	147.7	158.7	169.6	180.4	191.3	202.2	213.0
25	"	89.6	100.1	110.6	121.0	131.6	141.8	152.2	162.8	173.0	183.6	194.3	204.6
26	19½		96.3	106.2	116.2	126.5	136.3	146.5	156.5	166.4	176.8	186.8	196.8
27	"		92.7	102.4	112.0	121.8	131.3	141.0	150.8	160.2	170.2	180.0	189.5
28	"		89.3	98.7	108.0	117.4	126.7	136.0	145.4	154.7	164.1	173.4	182.6
29	"			95.4	104.2	113.4	122.3	131.3	140.3	149.3	158.4	167.3	176.4
30	"			92.2	100.8	109.4	118.2	126.8	135.8	144.3	153.2	161.9	170.5
32	"				94.5	102.8	110.8	119.0	127.3	135.2	143.6	151.8	159.8
34	"				88.9	96.7	104.2	111.9	119.8	127.3	135.1	142.9	150.4
36	"					91.4	98.4	105.7	113.2	120.2	127.4	135.0	142.1
38	"					86.6	93.3	100.1	107.1	113.9	120.9	127.8	134.6
40	"						88.6	95.2	101.8	108.1	114.9	121.4	127.8



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{8}$ $M_s = 16,000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd

" " " support = 150 bjd.

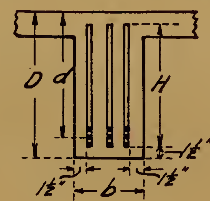
Stress in concrete = 750 #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = $1\frac{1}{2}$ sq. in.

Span in Feet	Width b inches	Total depth in inches (D). 8	10	12	14	16	18	20	22	24	26	28
6	$17\frac{1}{2}$		22.8	28.6								
7	"	14.5	19.5	24.5	29.5							
8	$13\frac{1}{2}$	12.7	17.1	21.5	25.8	30.2						
9	"		15.2	19.1	23.0	26.9	30.8					
10	"		13.6	17.2	20.7	24.2	27.7	31.2				
11	$9\frac{3}{4}$		12.4	15.6	18.8	22.0	25.2	28.3	31.5	34.7		
12	"		11.4	14.3	17.2	20.1	23.1	26.0	28.9	31.8		
13	$7\frac{3}{4}$			13.2	15.9	18.6	21.3	24.0	26.7	29.4	32.1	
14	"			12.3	14.7	17.3	19.8	22.3	24.8	27.3	29.8	32.3
15	"			11.4	13.8	16.1	18.4	20.8	23.1	25.4	27.8	30.1
16	"			10.7	12.9	15.1	17.3	19.5	21.7	23.9	26.0	28.2
17	"				12.2	14.2	16.3	18.3	20.4	22.4	24.5	26.6
18	"				11.5	13.4	15.4	17.3	19.3	21.2	23.2	25.1
19	"				10.9	12.7	14.6	16.4	18.2	20.1	21.9	23.8
20	"					12.1	13.8	15.6	17.3	19.0	20.8	22.6
21	"					11.5	13.2	14.8	16.5	18.2	19.8	21.5
22	"						12.6	14.2	15.8	17.3	18.9	20.5
23	"						12.0	13.5	15.1	16.6	18.1	19.6
24	"						11.5	13.0	14.4	15.9	17.4	18.8



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\,Ajd$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.
" " " support = 100 bjd.

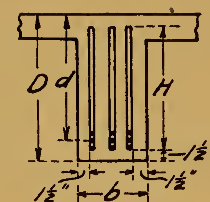
Stress in concrete = 750 #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. *Steel Area = $2\frac{1}{4}$ sq. in.*

Span in Feet	Width b inches	Total depth in inches (D). 10	12	14	16	18	20	22	24	26	28
8	$19\frac{1}{2}$	25.4	31.9	38.5	45.1						
9	"	22.5	28.4	34.2	40.1	45.9					
10	$15\frac{1}{2}$	20.3	25.5	30.8	36.0	41.3	46.5				
11	"	18.4	23.2	28.0	32.8	37.5	42.3	47.1	51.9		
12	"	16.9	21.3	25.7	30.0	34.4	38.8	43.2	47.6		
13	$11\frac{3}{4}$		19.6	23.7	27.7	31.8	35.8	39.8	43.9	47.9	
14	"		18.2	22.0	25.7	29.5	33.2	37.0	40.8	44.5	48.3
15	"		17.0	20.5	24.0	27.5	31.0	34.5	38.0	41.5	45.0
16	"		16.0	19.2	22.5	25.8	29.1	32.4	35.7	38.9	42.2
17	"			18.1	21.2	24.3	27.4	30.5	33.6	36.6	39.7
18	$8\frac{3}{4}$			17.1	20.0	22.9	25.9	28.8	31.7	34.6	37.5
19	"			16.2	19.0	21.7	24.5	27.2	30.0	32.8	35.5
20	"				18.2	20.6	23.3	25.9	28.5	31.2	33.8
22	"				16.4	18.8	21.2	23.5	25.9	28.3	30.7
24	"					17.2	19.4	21.6	23.8	26.0	28.1
26	"						17.9	19.9	22.0	24.0	26.0
28	"							18.5	20.4	22.3	24.1



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\ Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 100 bjd.

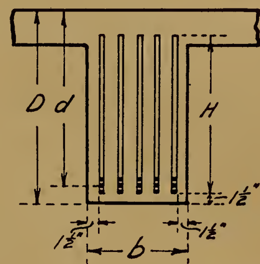
Stress in concrete = 750 #/sq. in.

Note:– Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. *Steel Area = $2\frac{1}{2}$ sq. in.*

Span in Feet.	Width b inches	Total depth in inches (D). 10	12	14	16	18	20	22	24	26	28.
9	$13\frac{1}{2}$	25.3	31.8	38.2							
10	$11\frac{3}{4}$	22.8	28.6	34.4	40.3						
11	"	20.7	26.0	31.3	36.6	41.9					
12	"	19.0	23.8	28.7	33.5	38.4	43.3				
13	"		22.0	26.5	31.0	35.5	39.9	44.4	48.9		
14	"		20.4	24.6	28.8	32.9	37.1	41.3	45.4	49.6	
15	"		19.1	23.0	26.8	30.7	34.6	38.5	42.4	46.3	
16	"		17.9	21.5	25.2	28.8	32.4	36.1	39.8	43.4	47.1
17	"			20.3	23.7	27.1	30.5	34.0	37.4	40.8	44.3
18	"			19.1	22.4	25.6	28.8	32.1	35.3	38.6	41.8
19	"			18.1	21.2	24.3	27.3	30.4	33.5	36.5	39.6
20	"				20.2	23.0	25.9	28.9	31.8	34.7	37.6
21	"				19.2	21.9	24.7	27.5	30.3	33.1	35.9
22	"					21.0	23.6	26.3	28.9	31.5	34.2
23	"					20.0	22.6	25.1	27.7	30.2	32.7
24	"					19.2	21.6	24.1	26.5	28.9	31.4



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\ Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = $50bjd$.

" " " support = $150bjd$.

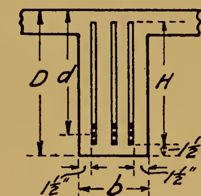
Stress in concrete = 750 #/sq. in.

Note.—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = 3 sq. in.

Span in Feet	Width b inches	Total depth in inches (D). 12	14	16	18	20	22	24	26	28	30	32	34	36
12	17½	27.8	33.6	39.5	45.3	51.1	57.0	62.8						
13	15½	25.6	31.0	36.4	41.8	47.2	52.6	58.0	63.3					
14	"	23.8	28.8	33.8	38.8	43.8	48.8	53.8	58.8	63.8	68.8			
15	13½	22.2	26.9	31.6	36.2	40.9	45.6	50.2	54.9	59.6	64.2	68.9		
16	"	20.8	25.2	29.6	34.0	38.4	42.7	47.1	51.5	55.9	60.3	64.6	69.0	73.3
17	11¾		23.7	27.9	32.0	36.1	40.2	44.3	48.4	52.6	56.7	60.8	64.9	69.0
18	"		22.4	26.3	30.2	34.1	38.0	41.9	45.7	49.6	53.5	57.4	61.3	65.2
19	"		21.2	24.9	28.6	32.3	36.0	39.7	43.3	47.0	50.7	54.4	58.1	61.8
20	"			23.7	27.2	30.7	34.2	37.7	41.2	44.7	48.2	51.7	55.2	58.7
21	9¾			22.6	25.9	29.2	32.5	35.9	39.2	42.5	45.9	49.2	52.5	55.9
22	"			21.5	24.7	27.9	31.1	34.3	37.4	40.6	43.8	47.0	50.1	53.4
24	8¾				22.6	25.6	28.5	31.4	34.3	37.2	40.2	43.1	46.0	48.9
26	"					23.6	26.3	29.0	31.7	34.4	37.1	39.8	42.4	45.2
28	"						24.4	26.9	29.4	31.9	34.4	36.9	39.4	41.9
30	"							25.1	27.4	29.8	32.1	34.5	36.8	39.1
32	"								25.7	27.9	30.1	32.3	34.5	36.7
34	"									26.3	28.3	30.4	32.5	34.5
36	"									24.8	26.8	28.7	30.7	32.6



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\, Ajd.$

$jd = \frac{7}{8} d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 100 bjd.

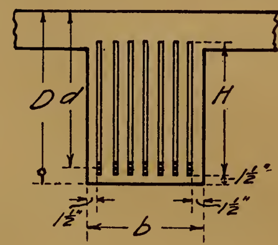
Stress in concrete = 750 #/sq. in.

Note:— Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = $3\frac{1}{2}$ sq. in.

Span in Feet.	Width b inches	Total depth in inches (D). 10	12	14	16	18	20	22	24	26	28.
10	$19\frac{1}{2}$		40.1	48.2	56.4						
11	$15\frac{1}{2}$		36.4	43.9	51.3						
12	"	26.6	33.4	40.2	47.0	53.8	60.6				
13	"	24.5	30.8	37.1	43.4	49.7	56.0	62.2			
14	"	22.8	28.6	34.5	40.3	46.2	51.9	57.8	63.6		
15	"		26.7	32.1	37.7	43.1	48.5	53.9	59.4	64.7	
16	"		25.1	30.1	35.3	40.4	45.5	50.6	55.7	60.8	65.8
17	"			28.4	33.2	38.0	42.8	47.6	52.4	57.2	62.0
18	"			26.8	31.4	35.9	40.4	44.9	49.5	54.0	58.5
19	"			25.4	29.7	34.0	38.3	42.6	46.9	51.1	55.4
20	"				28.2	32.3	36.4	40.4	44.6	48.6	52.6
21	"				26.9	30.8	34.7	38.5	42.4	46.3	50.1
22	"					29.4	33.1	36.7	40.5	44.1	47.9
23	"					28.1	31.7	35.1	38.7	42.3	45.8
24	"					26.9	30.3	33.7	37.1	40.5	43.9



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16,000\ Ajd$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50bjd.
" " " support = 150bjd.

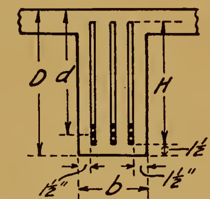
Stress in concrete = 750 #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = $3\frac{3}{4}$ sq. in.

Span in Feet	Width b inches	Total depth in inches (D). 14	16	18	20	22	24	26	28	30	32	34	36
13	$19\frac{1}{2}$	38.4	45.1	51.8	58.6	65.3	72.0	78.8	85.5	92.2			
14	"	35.6	41.9	48.1	54.4	60.6	66.9	73.1	79.4	85.6	91.9		
15	$17\frac{1}{2}$	33.3	39.1	44.9	50.7	56.6	62.4	68.2	74.1	79.9	85.7	91.6	97.4
16	"	31.2	36.6	42.1	47.6	53.0	58.5	64.0	69.5	74.9	80.4	85.8	91.3
17	$15\frac{1}{2}$	29.4	34.5	39.6	44.8	49.9	55.1	60.2	65.4	70.5	75.6	80.8	86.0
18	"	27.7	32.6	37.4	42.3	47.2	52.0	56.9	61.8	66.6	71.4	76.3	81.2
19	$13\frac{1}{2}$	26.2	30.9	35.5	40.1	44.7	49.3	53.9	58.5	63.1	67.7	72.3	76.9
20	"		29.3	33.7	38.1	42.4	46.8	51.2	55.6	60.0	64.3	68.7	73.1
21	"		27.9	32.1	36.3	40.4	44.6	48.8	52.9	57.1	61.2	65.4	69.6
22	$11\frac{3}{4}$		26.7	30.6	34.6	38.6	42.6	46.5	50.5	54.5	58.5	62.5	66.4
23	"		25.5	29.3	33.1	36.9	40.7	44.5	48.3	52.1	55.9	59.7	63.5
24	"			28.1	31.7	35.4	39.0	42.7	46.3	49.9	53.6	57.2	60.9
25	"			27.0	30.5	33.9	37.4	41.0	44.5	48.0	51.5	55.0	58.4
26	$9\frac{3}{4}$				29.3	32.6	36.0	39.4	42.6	46.1	49.5	52.8	56.2
28	"					30.3	33.4	36.6	39.7	42.8	46.0	49.1	52.2
30	"						31.2	34.1	37.0	40.0	42.8	45.8	48.7
32	"						29.3	32.0	34.7	37.5	40.2	42.9	45.7
34	"							30.2	32.7	35.3	37.8	40.4	43.0
36	"								30.9	33.3	35.7	38.2	40.6



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\,Ajd$.

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 100 bjd.

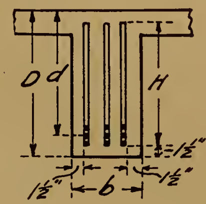
Stress in concrete = 750 #/sq. in.

Note:— Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area $= 4\frac{1}{2}$ sq. in.

Span in Feet.	Width b inches	Total depth in inches (D). 16	18	20	22	24	26	28	30	32	34	36.
15	20	46.4	53.4	60.4	67.4	74.4	81.4	88.4	95.4	102.4		
16	"	43.5	50.1	56.6	63.2	69.8	76.3	82.9	89.4	96.0	102.6	109.1
17	"	41.0	47.1	53.3	59.5	65.7	71.8	78.0	84.2	90.4	96.6	102.7
18	$17\frac{1}{2}$	38.7	44.5	50.4	56.2	62.0	67.9	73.7	79.5	85.4	91.2	97.0
19	"	36.6	42.2	47.7	53.2	58.7	64.3	69.8	75.3	80.9	86.4	91.9
20	$15\frac{1}{2}$	34.8	40.1	45.3	50.6	55.8	61.0	66.3	71.6	76.8	82.1	87.3
21	"	33.2	38.2	43.2	48.2	53.1	58.1	63.1	68.1	73.2	78.2	83.2
22	"	31.6	36.4	41.2	46.0	50.7	55.5	60.3	65.0	69.9	74.8	79.4
23	$13\frac{1}{2}$	4	34.8	39.4	44.0	48.5	53.1	57.6	62.2	66.8	71.3	75.9
24	"		33.4	37.8	42.2	46.5	50.9	55.3	59.6	64.0	68.4	72.8
25	"			36.3	40.5	44.7	48.8	53.1	57.2	61.4	65.6	69.9
26	$11\frac{3}{4}$			34.9	38.9	42.9	47.0	51.0	55.1	59.1	63.1	67.2
27	"				37.5	41.3	45.2	49.1	53.0	56.9	60.8	64.7
28	"					39.9	43.6	47.4	51.1	54.9	58.6	62.4
29	"					38.5	42.1	45.7	49.4	53.0	56.6	60.2
30	"					37.2	40.7	44.2	47.7	51.2	54.7	58.2
32	$9\frac{3}{4}$						38.2	41.4	44.7	48.0	51.3	54.6
34	"						35.9	39.0	42.1	45.2	48.3	51.3
36	"							36.8	39.7	42.7	45.6	48.5



Stress in steel $= 16{,}000$ #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d =$ effective depth.

Max. shear at first riser $= 50bjd.$

" " " support $= 100bjd.$

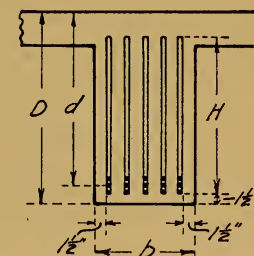
Stress in concrete $= 750$ #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = 5 sq. in.

Span in Feet.	Width b inches	Total depth in inches (D). 12	14	16	18	20	22	24	26	28	30	32	34	36.
13	$17\frac{1}{2}$		51.7	60.7	69.7	78.7	87.6	96.5						
14	"	39.8	48.0	56.3	64.7	73.1	81.3	89.7	98.1					
15	$15\frac{1}{2}$	37.1	44.8	52.6	60.4	68.2	75.9	83.7	91.5					
16	"	34.8	42.0	49.3	56.6	63.9	71.1	78.5	85.8	93.1	100.4			
17	$13\frac{1}{2}$		39.5	46.4	53.3	60.2	67.0	73.8	80.8	87.6	94.5	101.3		
18	"		37.3	43.8	50.3	56.8	63.3	69.7	76.3	82.8	89.3	95.7	102.2	
19	"		35.4	41.5	47.7	53.8	59.9	66.1	72.3	78.4	84.6	90.7	96.8	102.9
20	"			39.4	45.3	51.1	56.9	62.8	68.6	74.5	80.3	86.1	92.0	97.9
21	"			37.6	43.1	48.7	54.2	59.8	65.4	70.9	76.5	82.0	87.6	93.2
22	"			35.9	41.2	46.5	51.7	57.1	62.4	67.7	73.1	78.3	83.7	89.0
24	"				37.7	42.6	47.5	52.3	57.2	62.1	66.9	71.8	76.7	81.5
26	"					39.3	43.8	48.3	52.8	57.3	61.8	66.3	70.8	75.3
28	"						40.7	44.8	49.0	53.2	57.4	61.5	65.7	69.9
30	"							41.9	45.8	49.7	53.6	57.5	61.3	65.2
32	"								42.9	46.6	50.3	53.8	57.5	61.2
34	"									43.8	47.3	50.7	54.1	57.6
36	"									41.4	44.7	47.9	51.1	54.4



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\,Ajd$.

$jd = \frac{7}{8}d$ = effective depth

Max. shear at first riser = $50bjd$.

" " " support = $150bjd$.

Stress in concrete = 750 #/sq. in.

Note:- Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

5

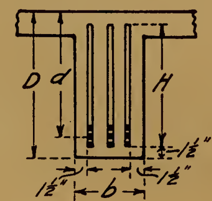
4

3

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = $5\frac{1}{4}$ sq. in.

Span in Feet.	Width b inches.	Total depth in inches (D). 18	20	22	24	26	28	30	32	34	36	38	40
15	$23\frac{1}{2}$	62.2	70.4	78.6	86.7	94.9	103.1	111.3	119.4				
16	"	58.3	66.0	73.6	81.3	89.0	96.6	104.1	111.9	119.6	127.3		
17	"	54.9	62.1	69.3	76.5	83.7	90.9	98.1	105.4	112.6	119.8	126.9	
18	$19\frac{1}{2}$	51.9	58.7	65.5	72.3	79.1	85.9	92.7	99.5	106.3	113.1	119.9	126.7
19	"	49.1	55.6	62.0	68.5	74.9	81.4	87.8	94.3	100.7	107.2	113.6	120.0
20	$17\frac{1}{2}$	46.7	52.8	58.9	65.1	71.2	77.3	83.4	89.5	95.7	101.8	107.9	114.0
21	"	44.4	50.3	56.1	62.0	67.8	73.6	79.5	85.3	91.1	97.0	102.7	108.6
22	"	42.4	48.0	53.6	59.2	64.7	70.3	75.9	81.4	87.0	92.6	98.1	103.6
23	$15\frac{1}{2}$	40.6	45.9	51.2	56.6	61.9	67.2	72.6	77.9	83.2	88.5	93.9	99.2
24	"		44.0	49.1	54.2	59.3	64.4	69.5	74.6	79.7	84.8	89.9	95.0
25	"		42.2	47.1	52.1	56.9	61.9	66.7	71.7	76.6	81.5	86.3	91.3
26	$13\frac{1}{2}$		40.6	45.3	50.1	54.8	59.5	64.2	68.9	73.6	78.3	83.1	87.7
27	"			43.6	48.2	52.8	57.3	61.8	66.3	70.9	75.4	79.9	84.5
28	"		4	42.1	46.5	50.9	55.2	59.6	64.0	68.4	72.7	77.1	81.5
29	"				44.9	49.1	53.3	57.6	61.8	66.0	70.1	74.5	78.7
30	$11\frac{3}{4}$				43.4	47.4	51.5	55.7	59.9	63.8	67.9	71.9	76.1
32	"					44.5	48.3	52.1	56.0	59.8	63.6	67.5	71.3
34	"					41.9	45.5	49.1	52.7	56.3	59.9	63.5	67.1
36	"						43.0	46.4	49.8	53.2	56.6	59.9	63.4



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.
" " " support = 100 bjd.

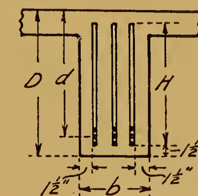
Stress in concrete = 750 #/sq. in.

Note:–
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = 6 sq. in.

Span in Feet	Width b inches	Total depth in inches (D). 20	22	24	26	28	30	32	34	36	38	40	42	44
17	$23\frac{1}{2}$	70.5	78.8	87.0	95.2	103.4	111.6	119.9	128.1	136.4	144.6			
18	"	66.6	74.4	82.2	90.0	97.7	105.5	113.3	121.0	128.8	136.6	144.4		
19	$21\frac{1}{2}$	63.1	70.5	77.9	85.2	92.6	100.0	107.3	114.7	122.0	129.4	136.8	144.1	
20	"	59.9	66.9	74.0	81.0	88.0	95.0	101.9	108.9	115.9	123.0	130.0	136.9	144.0
21	$19\frac{1}{2}$	57.1	63.7	70.4	77.1	83.8	90.4	97.1	103.7	110.4	117.1	123.8	130.4	137.1
22	"	54.5	60.8	67.2	73.6	80.0	86.3	92.7	99.0	105.4	111.8	118.1	124.5	130.8
23	$17\frac{1}{2}$	52.1	58.2	64.3	70.4	76.5	82.6	88.7	94.8	100.8	106.9	113.1	119.1	125.2
24	"	49.9	55.8	61.6	67.5	73.3	79.2	85.0	90.8	96.6	102.5	108.4	114.1	120.0
25	"	48.0	53.5	59.2	64.8	70.4	76.0	81.6	87.2	92.8	98.5	104.0	109.6	115.2
26	$15\frac{1}{2}$	46.1	51.5	56.9	62.3	67.7	73.0	78.4	83.8	89.2	94.7	100.0	105.3	110.8
27	"		49.6	54.8	60.0	65.2	70.3	75.5	80.7	85.9	91.1	96.3	101.4	106.6
28	"		47.8	52.8	57.8	62.8	67.8	72.8	77.8	82.8	87.9	92.9	97.8	102.8
29	"			51.0	55.8	60.7	65.5	70.3	75.1	80.0	84.9	89.7	94.5	99.3
30	$13\frac{1}{2}$			49.3	54.0	58.7	63.3	68.0	72.6	77.3	82.0	86.7	91.3	96.0
32	"				50.6	55.0	59.3	63.7	68.1	72.5	76.9	81.3	85.8	90.0
34	"				47.6	51.8	55.9	60.0	64.1	68.2	72.3	76.5	80.6	84.7
36	"					48.9	52.7	56.7	60.5	64.4	68.3	72.3	76.1	80.0
38	"					46.3	50.0	53.7	57.4	61.0	64.7	68.4	72.1	75.8
40	"						47.5	51.0	54.5	58.0	61.5	65.0	68.5	72.0



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 100 bjd.

Stress in concrete = 750 #/sq. in.

Note:– Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

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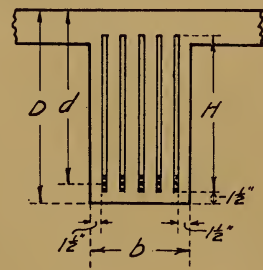
Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams.

Steel Area = $6\frac{1}{4}$ sq. in.

Span in Feet.	Width b inches	14	16	18	20	22	24	26	28	30	32	34	36.
13	$21\frac{1}{2}$		75.1	86.4	97.7	108.8	120.0						
14	"		69.8	80.3	90.7	101.1	111.4	121.8					
15	$18\frac{1}{2}$	55.4	65.1	74.9	84.6	94.3	104.0	113.7	123.5	133.2			
16	"	51.9	61.0	70.2	79.3	88.5	97.5	106.6	115.7	124.9	134.0	143.1	
17	"	48.9	57.5	66.1	74.7	83.2	91.8	100.4	108.9	117.6	126.1	134.6	143.3
18	$15\frac{1}{2}$	46.2	54.3	62.4	70.5	78.6	86.7	94.8	102.9	111.1	119.1	127.1	135.4
19	"	43.7	51.4	59.1	66.8	74.5	82.1	89.8	97.5	105.1	112.8	120.5	128.2
20	"		48.8	56.1	63.5	70.7	78.0	85.3	92.7	99.9	107.2	114.4	121.8
21	$13\frac{1}{2}$		46.5	53.5	60.5	67.3	74.3	81.3	88.2	95.2	102.1	109.0	116.0
22	"		44.4	51.1	57.7	64.3	70.9	77.6	84.2	90.9	97.5	104.1	110.7
23	"		42.5	48.8	55.2	61.5	67.8	74.2	80.5	86.9	93.3	99.5	105.9
24	"			46.8	52.9	58.9	65.0	71.1	77.2	83.3	89.3	95.4	101.5
25	"			45.0	50.8	56.6	62.4	68.3	74.1	79.9	85.8	91.6	97.5
26	"				48.8	54.4	60.0	65.6	71.3	76.9	82.5	88.1	93.7
28	"					50.5	55.7	60.9	66.1	71.4	76.6	81.8	87.0
30	"						52.0	56.9	61.7	66.7	71.5	76.3	81.2
32	"						48.8	53.3	57.9	62.5	67.0	71.5	76.1
34	"							50.2	54.5	58.8	63.1	67.3	71.7
36	"								51.5	55.5	59.6	63.6	67.7



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $\quad M_s = 16{,}000\,Ajd$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 150 bjd.

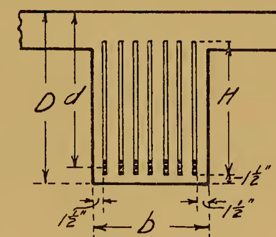
Stress in concrete = 750 #/sq. in.

Note:— Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = 7 sq. in.

Span in Feet	Width b inches	Total depth in inches (D). 14	16	18	20	22	24	26	28	30	32	34	36.
13	26½			97.5	110.1								
14	23½		79.0	90.6	102.2	113.9	125.6						
15	"		73.7	84.5	95.4	106.3	117.2	128.1					
16	19½	58.8	69.1	79.3	89.5	99.7	109.9	120.1					
17	"	55.4	65.1	74.6	84.2	93.8	103.4	113.1	122.6	132.3			
18	"	52.3	61.5	70.5	79.5	88.6	97.7	106.7	115.8	124.9	134.0		
19	16½	49.6	58.2	66.8	75.3	83.9	92.6	101.1	109.7	118.4	127.0		
20	"	6	55.3	63.4	71.5	79.7	87.9	96.1	104.2	112.4	120.6	128.7	136.9
21	"		52.7	60.3	68.2	75.9	83.8	91.5	99.3	107.1	114.9	122.6	130.4
22	"		50.3	57.7	65.1	72.5	79.9	87.3	94.8	102.2	109.6	117.1	124.4
24	"		5	52.9	59.7	66.4	73.3	80.1	86.9	93.7	100.6	107.3	114.1
26	"				55.1	61.3	67.7	73.9	80.2	86.5	92.8	99.1	105.3
28	"					56.9	62.8	68.6	74.5	80.3	86.2	91.9	97.8
30	"						58.7	64.1	69.5	75.0	80.5	85.9	91.3
32	"							60.1	65.2	70.3	75.4	80.5	85.6
34	"								61.3	66.1	71.0	75.7	80.5
36	"								57.9	62.5	67.1	71.5	76.1



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16,000\,Ajd$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50bjd.

" " " support = 150bjd.

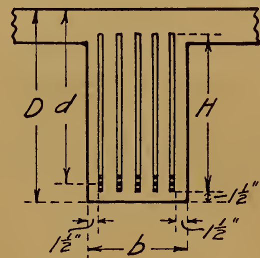
Stress in concrete = 750 #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = $7\frac{1}{2}$ sq. in.

Span in Feet.	Width b inches	16	18	20	22	24	26	28	30	32	34	36	38	40
		Total depth in inches (D).												
15	$23\frac{1}{2}$	77.3	89.0	100.7	112.3	124.0	135.7							
16	$21\frac{1}{2}$	72.5	83.5	94.5	105.3	116.2	127.2	138.1	149.1					
17	"	68.2	78.5	88.9	99.1	109.4	119.7	130.0	140.3	150.6				
18	"	64.4	74.2	83.9	93.6	103.3	113.1	122.8	132.5	142.3	151.9	161.7		
19	$17\frac{1}{2}$	61.0	70.3	79.5	88.7	97.9	107.1	116.4	125.5	134.8	143.9	153.1	162.4	
20	"	58.0	66.7	75.5	84.2	93.0	101.8	110.5	119.2	128.1	136.7	145.5	154.2	
21	"	55.2	63.6	71.9	80.2	88.6	96.9	105.2	113.6	121.9	130.3	138.6	146.9	155.2
22	$15\frac{1}{2}$	52.7	60.7	68.7	76.6	84.6	92.5	100.4	108.4	116.4	124.4	132.3	140.2	148.2
23	"		58.1	65.7	73.3	80.9	88.5	96.1	103.6	111.4	118.9	126.6	134.1	141.7
24	"		55.6	62.9	70.2	77.5	84.8	92.1	99.4	106.7	113.9	121.2	128.5	135.8
25	$13\frac{1}{2}$			60.5	67.4	74.4	81.5	88.4	95.4	102.4	109.4	116.4	123.4	130.4
26	"			58.1	64.8	71.5	78.3	85.0	91.7	98.5	105.2	111.9	118.6	125.3
27	"				62.4	68.9	75.4	81.9	88.3	94.9	101.4	107.7	114.3	120.7
28	"				60.2	66.4	72.7	78.9	85.2	91.5	97.7	103.9	110.2	116.4
29	"					64.1	70.2	76.2	82.3	88.3	94.3	100.4	106.4	112.4
30	"					62.0	67.9	73.7	79.5	85.4	91.2	97.0	102.8	108.6
32	"						63.6	69.1	74.5	80.1	85.5	90.9	96.4	101.8
34	"						59.9	65.0	70.1	75.4	80.5	85.6	90.8	95.9
36	"							61.4	66.3	71.2	76.0	80.9	85.7	90.6



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\, Ajd.$

$jd = \frac{7}{8} d =$ effective depth.

Max. shear at first riser = $50bjd$.

" " " support = $150bjd$.

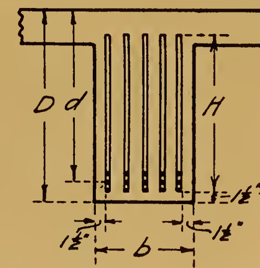
Stress in concrete = 750 #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = $8\frac{3}{4}$ sq. in.

Span in Feet	Width b inches	Total depth in inches (D). 18	20	22	24	26	28	30	32	34	36	38	40
15	26		117.3	130.9	144.6	158.2							
16	$24\frac{1}{2}$	97.3	110.0	122.7	135.6	148.3	161.1	173.8					
17	"	91.5	103.5	115.5	127.6	139.6	151.6	163.6	175.6				
18	"	86.5	97.7	109.1	120.5	131.8	143.2	154.5	165.9	177.1	188.6		
19	$21\frac{1}{2}$	81.9	92.7	103.4	114.2	124.9	135.6	146.4	157.1	167.8	178.6	189.3	
20	$19\frac{1}{2}$	77.8	88.0	98.2	108.4	118.6	128.9	139.1	149.2	159.4	169.7	179.8	
21	"	74.1	83.8	93.5	103.3	113.1	122.8	132.5	142.1	151.8	161.6	171.3	181.1
22	"	70.7	80.0	89.3	98.7	107.9	117.2	126.4	135.6	144.9	154.3	163.5	172.8
23	$17\frac{1}{2}$	67.7	76.5	85.4	94.3	103.2	112.1	120.9	129.8	138.6	147.6	156.4	165.2
24	"		73.3	81.9	90.4	98.9	107.4	115.9	124.4	132.9	141.4	149.8	158.4
25	"		70.4	78.6	86.8	95.0	103.1	111.3	119.4	127.6	135.8	143.9	152.1
26	$15\frac{1}{2}$		67.7	75.6	83.5	91.3	99.2	106.9	114.8	122.6	130.6	138.3	146.2
27	"			72.7	80.4	87.9	95.5	103.0	110.5	118.1	125.8	133.2	140.8
28	"			70.1	77.5	84.8	92.1	99.3	106.6	113.8	121.2	128.4	135.8
29	"				74.8	81.9	88.9	95.9	102.9	109.9	117.1	124.1	131.1
30	"				72.3	79.1	85.9	92.7	99.5	106.3	113.1	119.8	126.7
32	"					74.2	80.5	86.9	93.3	99.7	106.1	112.4	118.8
34	"					69.8	75.8	81.8	87.8	93.8	99.9	105.8	111.8
36	"						71.6	77.3	82.9	88.6	94.3	99.9	105.6



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\, Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50bjd

" " " support = 150bjd.

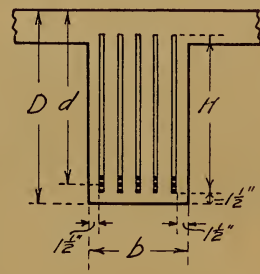
Stress in concrete = 750 #/sq. in.

Note:— Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = 10 sq. in.

Span in Feet.	Width b inches	20	22	24	26	28	30	32	34	36	38	40	42.
		Total depth in inches (D).											
17	$26\frac{1}{2}$	117.5	131.4	145.1	158.7	172.4	186.3	200.0					
18	"	110.9	124.1	137.0	149.9	162.9	175.9	188.9	201.7	214.8			
19	$23\frac{1}{2}$	105.2	117.5	129.8	142.0	154.3	166.6	178.9	191.1	203.4	215.8		
20	"	99.9	111.6	123.3	134.9	146.6	158.3	170.0	181.6	193.3	204.9		
21	$21\frac{1}{2}$	95.1	106.4	117.4	128.5	139.6	150.8	161.9	172.9	184.1	195.1	206.2	
22	"	90.8	101.5	112.1	122.6	133.4	143.9	154.5	165.7	175.7	186.3	196.8	207.4
23	$19\frac{1}{2}$	86.9	97.1	107.3	117.3	127.5	137.6	147.8	157.8	168.1	178.2	188.3	198.5
24	"	83.3	93.1	102.8	112.4	122.1	131.9	141.6	151.3	161.1	170.7	180.4	190.2
25	"	79.9	89.3	98.7	107.9	117.3	126.6	136.0	145.3	154.6	163.9	173.3	182.5
26	$17\frac{1}{2}$	76.9	85.9	94.9	103.8	112.7	121.8	130.8	139.7	148.7	157.6	166.6	175.5
27	"		82.7	91.3	99.9	108.6	117.3	125.8	134.5	143.2	151.8	160.4	169.1
28	"		79.7	88.1	96.4	104.7	113.1	121.4	129.6	138.1	146.4	154.7	163.0
29	$15\frac{1}{2}$			85.1	93.1	101.1	109.2	117.2	125.2	133.3	141.4	149.4	157.4
30	"			82.2	89.9	97.7	105.6	113.3	121.1	128.8	136.6	144.4	152.1
32	"				84.3	91.7	99.0	106.2	113.5	120.7	128.1	135.4	142.6
34	"				79.3	86.3	93.1	99.9	106.8	113.6	120.6	127.4	134.2
36	"					81.5	87.9	94.5	100.8	107.4	113.8	120.3	126.8
38	"					77.1	83.3	89.5	95.5	101.7	107.8	114.0	120.2
40	"						79.2	85.1	90.8	96.7	102.4	108.3	114.1



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\,Ajd$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 150 bjd.

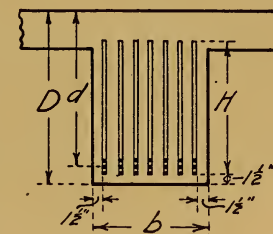
Stress in concrete = 750 #/sq. in.

Note.—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = $10\frac{1}{2}$ sq. in.

Span in Feet.	Width b inches	18	20	22	24	26	28	30	32	34	36	38	40
		Total depth in inches (D).											
15	31			157.4	173.7	189.9							
16	"		132.2	147.5	162.8	178.0							
17	$27\frac{1}{2}$		124.2	138.8	153.3	167.5	182.0	196.4					
18	"	103.9	117.3	131.1	144.8	158.2	171.9	185.4					
19	25	98.3	111.1	124.2	137.1	149.8	162.8	175.7	188.6				
20	$23\frac{1}{2}$	93.7	105.6	118.0	130.2	142.4	154.6	166.9	179.1	191.4	203.7		
21	"	89.1	100.6	112.4	124.1	135.6	147.3	159.0	170.6	182.3	193.8	205.8	
22	$21\frac{1}{2}$	84.9	96.0	107.3	118.4	129.5	140.6	151.7	162.8	174.0	185.1	196.4	207.4
23	"	81.4	91.9	102.6	113.3	123.8	134.5	145.1	155.8	166.4	177.2	187.8	198.4
24	$19\frac{1}{2}$	77.8	88.0	98.3	108.6	118.6	128.8	139.1	149.2	159.5	169.6	179.9	190.1
25	"		84.5	94.4	104.2	113.9	123.7	133.6	143.3	153.1	162.8	172.7	182.6
26	$18\frac{1}{2}$		81.3	90.8	100.2	109.6	119.0	128.4	137.8	147.2	156.6	166.2	175.5
27	"			87.5	96.5	105.5	114.6	123.6	132.7	141.8	150.8	160.0	169.0
28	"			84.3	93.1	101.7	110.5	119.2	127.9	136.6	145.4	154.3	163.1
29	"				89.9	98.2	106.6	115.1	123.5	132.0	140.4	149.0	157.4
30	"				86.9	94.9	103.1	111.3	119.4	127.6	135.8	144.0	152.1
32	"					89.0	96.7	104.4	111.9	119.6	127.2	134.9	142.6
34	"					83.8	91.0	98.2	105.4	112.6	119.7	127.0	134.3
36	"						85.9	92.7	99.5	106.4	113.1	119.9	126.8



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16,000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = $50bjd.$

" " " support = $150bjd.$

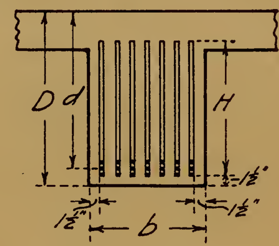
Stress in concrete = 750 #/sq. in.

Note:— Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = $12\frac{1}{4}$ sq. in.

Span in Feet	Width b inches	18	20	22	24	26	28	30	32	34	36	38	40
		Total depth in inches (D).											
16	34				189.6	207.5							
17	"			161.7	178.5	195.3	212.1	229.0					
18	$30\frac{1}{2}$			152.7	168.6	184.5	200.2	216.1	232.1				
19	"		129.6	144.6	159.7	174.7	189.7	204.9	219.9				
20	$27\frac{1}{2}$		123.2	137.4	151.7	166.0	180.3	194.6	208.9	223.2	237.5		
21	"	103.8	117.4	130.9	144.6	158.1	171.7	185.4	198.9	212.9	226.2		
22	"	99.1	112.1	124.9	138.0	150.9	163.8	176.9	189.9	203.1	216.0		
23	$24\frac{1}{2}$		107.1	119.5	131.9	144.3	156.8	169.3	181.6	194.4	206.7	219.0	231.2
24	"		102.7	114.5	126.4	138.4	150.3	162.2	174.1	186.2	198.0	209.8	221.7
25	"		98.7	109.9	121.4	132.8	144.3	155.7	167.1	178.6	190.0	201.5	212.8
26	$21\frac{1}{2}$		94.8	105.7	116.7	127.7	138.7	149.7	160.7	171.7	182.8	193.6	204.7
27	"			101.8	112.4	123.0	133.6	144.1	154.7	165.3	176.0	186.5	197.0
28	$19\frac{1}{2}$			98.2	108.4	118.6	128.8	139.1	149.2	159.6	169.8	179.7	190.0
29	"				104.6	114.4	124.4	134.2	144.1	154.1	163.9	173.5	183.4
30	"				101.2	110.6	120.2	129.7	139.2	148.8	158.4	167.8	177.3
32	"					103.7	112.6	121.6	130.5	139.6	148.5	157.3	166.2
34	"					97.7	106.1	114.5	122.9	131.4	139.8	148.1	156.4
36	"						100.2	108.1	116.1	124.1	132.0	139.8	147.7



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 150 bjd.

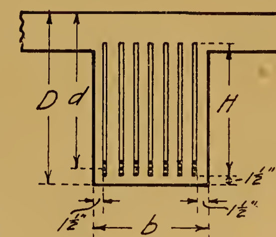
Stress in concrete = 750 #/sq. in.

Note:—
Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Safe total load in thousands of pounds uniformly distributed for concrete T beams.

Continuous Beams. Steel Area = 14 sq. in.

Span in Feet	Width b inches	Total depth in inches (D). 20	22	24	26	28	30	32	34	36	38	40	42
17	37				222.2	241.8	260.8						
18	"			191.7	210.0	228.1	246.1	264.3					
19	34½			181.6	198.9	216.1	233.1	250.6	267.8				
20	"		156.2	172.6	188.9	205.0	221.6	237.9	254.2				
21	31½	133.3	148.8	164.3	180.0	195.6	211.0	226.8	242.2	257.8	273.2		
22	28½	127.2	142.1	157.0	171.8	186.7	201.5	216.2	231.2	246.0	261.0	275.9	
23	"	121.6	135.9	150.1	164.4	178.6	192.6	206.9	221.2	235.1	249.6	263.9	
24	26	116.6	130.2	143.8	157.5	171.1	184.6	198.4	211.9	225.5	239.1	252.8	266.3
25	"	111.9	125.0	138.1	151.2	164.3	177.3	190.4	203.5	216.4	229.7	242.8	255.8
26	24		120.2	132.8	145.4	158.0	170.4	183.1	195.6	208.1	220.8	233.3	245.9
27	"		115.7	127.8	140.0	152.1	164.1	176.3	188.4	200.3	212.7	224.8	236.8
28	"		111.6	123.3	135.0	146.7	158.3	170.0	181.6	193.3	205.0	216.8	228.3
29	21½			119.0	130.4	141.6	152.8	164.2	175.4	186.6	197.8	209.1	220.4
30	"			115.1	126.0	136.8	147.7	158.6	169.6	180.4	191.4	202.2	213.1
32	19½				118.1	128.4	138.5	148.7	159.0	169.1	179.3	189.6	199.7
34	"				111.1	120.8	130.4	140.0	149.6	159.1	168.8	178.4	188.1
36	"					114.1	123.1	132.2	141.3	150.4	159.4	168.5	177.6
38	"					108.1	116.6	125.3	133.8	142.4	151.0	159.6	168.2
40	"						110.8	119.0	127.2	135.3	143.4	151.6	159.8



Stress in steel = 16,000 #/sq. in.

$M = \frac{Wl}{10}$ $M_s = 16{,}000\,Ajd.$

$jd = \frac{7}{8}d$ = effective depth.

Max. shear at first riser = 50 bjd.

" " " support = 150 bjd.

Stress in concrete = 750 #/sq. in.

Note:– Minimum thickness of slab for values within adjoining heavy lines given by large open numbers.

Sewers and Conduits

REINFORCED concrete sewers and conduits were developed early in the history of reinforcement. The resistance to corrosion of this material in damp and wet soil and its susceptibility to special design over uncertain ground and through varying depths of fill, alike drew the attention of engineers to its possibilities. With the installment of the first reinforced concrete sewer, "Steelcrete" expanded metal mesh entered this field of usefulness and the long list of notable sewers, conduits, culverts and like structures in which this material has been used bears indisputable evidence to the adaptibility of this reinforcement to this type of structure. "Steelcrete" mesh possesses the happy combination of the two essential requirements: (1) that of being theoretically correct, (2) that of being essentially practical. We submit twelve reasons why "Steelcrete" mesh is superior for this particular type of structure to all other fabricated meshes or systems of reinforcement. Six of these reasons are theoretical considerations and six practical ones.

Conditions in Practice

On account of the uncertain nature and material of the foundations of ordinary sewers and the varying conditions of the point of application, as well as the direction and the amount of the loads, the design of sewers is rarely susceptible to a rigid mathematical investigation. Our table of sizes and reinforcement, found elsewhere in this chapter, is not based on a mathematical analysis, but on good modern practice. For a more complete discussion of the design of reinforced concrete sewers we would refer you to an article by Mr. Ernest McCullough in Engineering Record of February 27, 1909, and Bulletin No. 22, University of Illinois, April 29, 1908.

The following article is reprinted by permission of Mr. Arthur N. Talbot from Bulletin No. 22, University of Illinois, dated April 29, 1908 on reinforced concrete culvert pipe, etc.

Conditions of Bedding and Loading Found in Practice

"If the layer of earth immediately under the pipe is hard or uneven, or if the bedding of the pipe at either side is soft material or not well tamped, the main bearing of the pipe may be along an element at the bottom and the result is in effect concentrated loading. The result is to greatly increase the bending moment developed and hence the tendency of the pipe to fail. This condition may be aggravated in the case of a pipe with a stiff hub or bell where settlement may bring an unusual proportion of the bearing at the bell and the distribution of the pressure be far from the assumed condition. In bedding the pipe in hard ground it is much better to form the trench so that the pipe will surely be free along the bottom element, even after settlement occurs, so that the bearing pressure may tend to concentrate at points say under the one third points of the horizontal diameter (or even the outer quarter points). This will reduce the bending moments developed in the ring.

"In case the pipe is bedded in loose material, the effect of the settlement will be to compress the earth immediately under the bottom of the pipe more completely than will be the effect at one side, with the result that the pressure will not be uniformly distributed horizontally. Similarly, in a sewer trench, if loose material is left at the sides and the material at the extremity of the horizontal diameter is loose and offers little restraint, the pressure on the earth will not be distributed horizontally and the amount of bending moment will be materially different from that where careful bedding and tamping give an even distribution of bearing pressure over the bottom of the sewer.

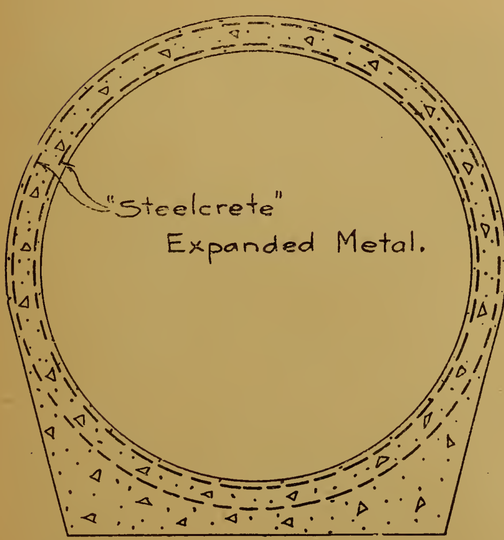
"In case a small sewer in a deep trench, the load upon the sewer may be materially less than the weight on the earth above, where the earth forms a hard, compact mass and is held by pressure and friction against the side of the trench.

"In case a culvert pipe is laid in an ordinary embankment by cutting down the sides slopingly, it is evident that the load which comes upon the pipe will be materially less than the weight of the earth immediately above it. If a culvert pipe

replaces a trestle and the filling is allowed to run down the slope, the direction and amount of the pressure against the pipe will differ considerably from that which obtains in a trench or in the case of a level filling. It is possible in the latter case that the small amount of settlement of the earth directly over the culvert pipe, due to the greater depth of earth on the adjacent sections, may allow a greater proportion of the load to rest upon the culvert pipe than would ordinarily be assumed.

"Attention should be called to the fact that the distribution of the pressure by means of earth under and over a ring assumes that the earth is compressed in somewhat the same way as when other material of construction is given compression. Unless the earth has elasticity, the distribution of the pressure cannot occur. To secure the uniform distribution assumed the ring itself must give enough to allow for the movement of the earth which takes place under pressure. This is especially true with reference to the presence and utilization of lateral restraint, and a ring which does not give laterally, as for example a plain concrete ring will not develop lateral pressure in the adjoining earth under ordinary conditions of moisture and filling to any great extent. As the conditions of earth and moisture produce mobility and approach hydrostatic conditions, the necessity for this elasticity and movement do not exist, but here the lateral pressure approaches the vertical pressure in amount and the bending moments become relatively smaller.

"The discussion is sufficiently extended to indicate the importance of care in bedding culvert pipe and sewers and in filling over them, and to indicate the great difference in the amount of bending moment developed with different conditions of bedding and filling. Where there is any question of needed strength, it will be money well expended to use care and precaution in bedding the pipe and in filling around and over it. I am convinced that a little extra expense will add considerable stability, life, strength, and safety to such structures, far out of proportion to the added cost. It is possible that under careful conditions of laying, lighter structures may be used with a saving in the cost of construction."



Sketches showing position of reinforcement in circular sewers and conduits given in accompanying tables. Note that when using one layer of reinforcement the steel should be within one inch of the inside surface at the top and bottom of the ring and within one inch of the outside surface at the sides. When two layers of reinforcement are used they should be within one inch of the inside and outside surface as shown in the lower sketch.

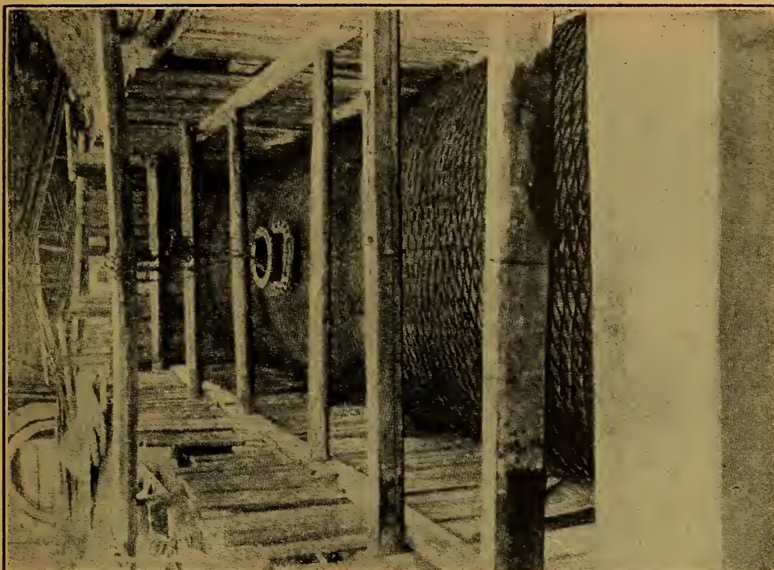
Tables of "Steelcrete" Reinforcement for Sewers and Conduits

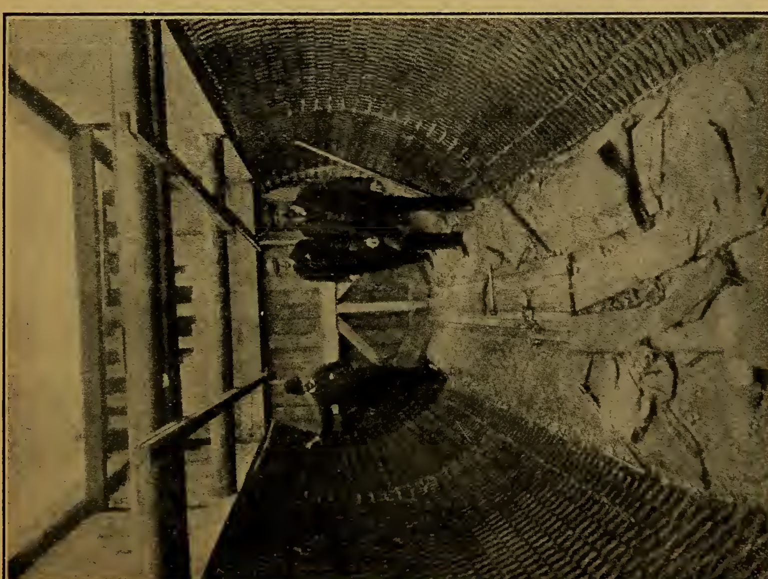
Inside Diameter	Thickness of Concrete	Size of Expanded Metal
2′ 6″	3½″	3-9-15
3′ 0″	3½″	3-9-20
3′ 6″	3½″	3-9-20
4′ 0″	3½″	3-9-25
4′ 6″	4″	3-9-25
5′ 0″	4½″	3-9-30
5′ 6″	5″	3-9-30
6′ 0″	5½″	3-9-35
6′ 6″	6″	3-9-35
7′ 0″	6½″	3-6-40
7′ 6″	7″	3-6-45
8′ 0″	7½″	3-6-50

For egg shaped sewers use same size of expanded metal and thickness of concrete, the diameter given in the table being the horizontal diameter.

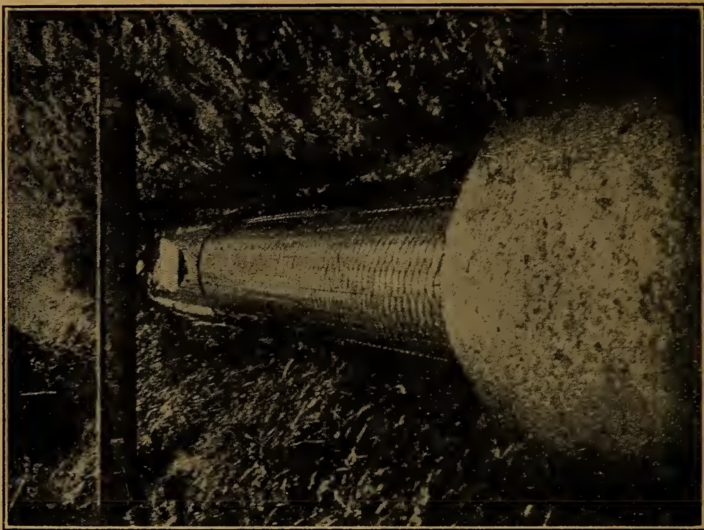
Under ordinary conditions these sewers may be used for any depth of fill and when required to sustain a heavy live load, such as a road roller, the depth of fill should be not less than 3′ 0″ for the given size of reinforcement. When severe conditions of loading and bedding are encountered it is preferable to use two layers of expanded metal, one near the inside and one near the outside. A double reinforcement will generally provide for all contingencies. When using two layers of "Steelcrete" reinforcement select the next size of mesh lighter than that shown in the table.

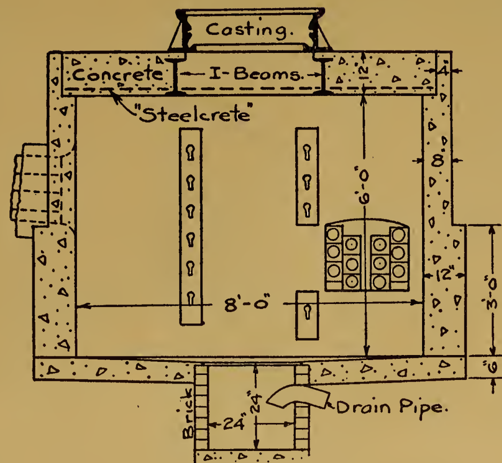
It is important to note that in placing "Steelcrete" reinforcement in sewers and conduits the long way of the diamond should lie in the direction of the circumference and the short way of the diamond in the direction of the axis of the pipe. This will give the strongest method of reinforcement.

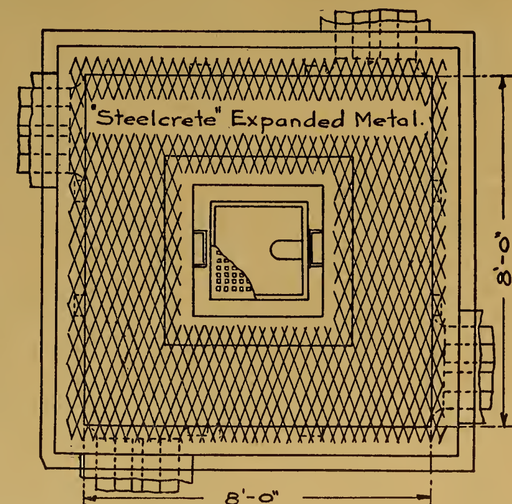




Typical views of a large concrete pipe, reinforced with Expanded Metal, in course of construction







Standard Manholes used in New York City by the Consolidated Telegraph and Electrical Subway Co., Mr. Edwin R. Quimby, Chief Engineer. Nearly 4000 of these in use in New York City alone. The cover is a slab, reinforced with "Steelcrete" Expanded Metal, resting on I-beams, and consumes the minimum amount of space, thus giving the largest obtainable room for operations in the chamber. This construction is found to be the most durable and economical. Where marshy soil is encountered expanded metal is placed in the sides and bottom also

Circular, Square and Rectangular Concrete Tanks

Liquid Contents

THE tables given herewith may be used only when the tank is intended to contain water or a lighter liquid. When it is desired to design a tank for any liquid heavier than water the following tables do not apply.

Introduction to Tables

The figures given in these tables designate in an abbreviated form the size of "Steelcrete" mesh required as a reinforcement in the vertical wall of the tank. For convenience these are given here:

075 designates mesh..3-13-075	35 designates mesh..3-9-35
10 designates mesh..3-13-10	40 designates mesh..3-6-40
125 designates mesh..3-13-125	45 designates mesh..3-6-45
15 designates mesh..3- 9-15	50 designates mesh..3-6-50
20 designates mesh..3- 9-20	55 designates mesh..3-6-55
25 designates mesh..3- 9-25	60 designates mesh..3-6-60
30 designates mesh..3- 9-30	

For standard size of sheets, weight per square foot and other details of each size of mesh, page 250 of "Steelcrete" handbook should be consulted.

Circular Tanks

Let it be required to design a circular tank of 20 feet internal diameter and inside depth of 20 feet. It is desired to know the reinforcement in the same and the thickness of the outer shell. From table 1, page 168, there is obtained the following data:

¼ - 075
30
50
40 - 40

The first line ¼ - 075 gives the fractional part of the sheet, constituting the top layer of reinforcement, which in this case is 3-13-075. The second line gives the size of the next rein-

forcing sheet 3-9-30. The third line gives the next size sheet 3-6-50. The last line calls for two sheets of mesh 3-6-40 at the bottom of the wall. The correct position of the reinforcement is shown in Figure 9. It should be remembered that the width of the sheet (the short direction of the diamonds) is the vertical direction of the sheet in the outer shell and the length of the sheet (indicated by the long direction of the diamonds) is the horizontal direction of the sheet. The sheets of mesh should be lapped eight inches or more, as the case may be, on the ends, and three inches or more on the sides.

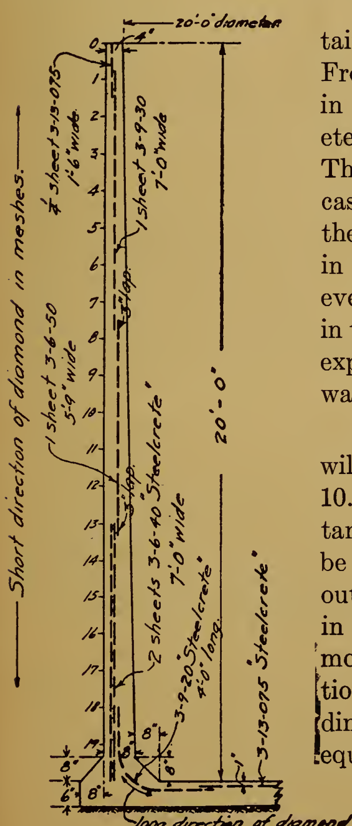


Fig. (9)

Let it now be required to ascertain the thickness of the outer shell. From table 2, the thickness given in inches of a tank 20 feet in diameter and 20 feet in depth is 8 inches. The thickness at the top is in every case 4 inches. The inside face of the wall may be battered as shown in Figure 9, or be stepped off in even inches at the height indicated in the table. It may even be deemed expedient at times to make the wall of even thickness throughout.

Details

The details of a circular tank will be noted from Figures 9 and 10. The thickness of the floor of a tank resting on hard ground should be equal to the thickness of the outer wall at the bottom, as given in table 2 except that it need not be more than 6 inches on good foundation. Referring to Figure 10, the dimensions A and B should be all equal to the thickness of the outer wall at the bottom with the limitation on dimensions B as noted above.

The floor of the tank may be made monolithic, in which case it should be reinforced as shown in Figure 9 with "Steelcrete" mesh 3-13-075. The side walls should be securely tied to the floor, as indicated in the same figure, with 3-9-20, except that where the lower layer of mesh on the side walls is of a lighter size, that same size may be used for this purpose.

Details of Construction

The life and efficiency of a concrete tank depend upon its impermeability or resistance to leakages. Whether waterproofing compounds are used or not, no detail is more important to observe than that all the concrete should be poured in as nearly one operation as possible. If it is not possible to do this in one operation, the floor should be made in one and the outer shell in another. This is of so great importance that the designer should not hesitate to insist on day and night work to attain this end. This brings us to the subject of waterproofing.

Waterproofing

The concrete should contain no stone larger than three-quarters of an inch in any dimension and the material should be carefully graded so that all voids will be well filled. Good concrete is the cheapest and best waterproofing. It has been demonstrated that a properly proportioned and properly mixed concrete may be made practically waterproof. It is nevertheless

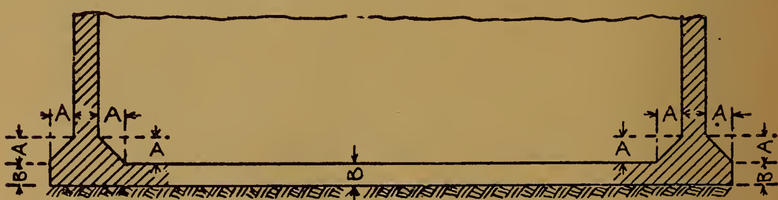


Fig. (10)

advisable to take every precaution possible. The concrete should be thoroughly mixed to a wet consistency and well tamped. Any good waterproofing compound which may be obtained in the market should be mixed with the concrete. The inside of the tank should be plastered with cement mortar or grouted with neat cement.

Roof Tanks

If a tank is required to be elevated as on a roof or water tower, the walls may be designed with the use of the tables, as given herewith. The floor, however, becomes a special design and here the services of an engineer should be sought.

Sunken Tanks

If a tank is to be sunk in the ground, the tables herewith given may be used to aid in the design. The external earth pressure counteracts the internal pressure and serves to give the tank additional stability when the tank is full. When the tank is empty the external pressure may reverse the stresses in the wall. In every case, therefore, two sheets of reinforcement should be used, one placed near the outer surface and the other near the inner one. The size of mesh near each surface may be of half the weight of the size called for in the tables; for example, if 3-6-40 is required, two sheets of 3-9-20 placed as stated above should be used. This rule will apply only for tanks up to 20 feet internal diameter. For tanks of greater internal diameter, the design is somewhat complicated, and it is recommended that the reinforcement called for in the tables should be placed near one surface and a like amount near the other surface of the wall.

How to Design a Square Tank

In table 3 the size of mesh required to reinforce the walls of a square tank is given. Table 4 gives the thickness of the concrete walls. The arrangement and location of the reinforcement in the wall is shown in Figure 11, which shows the details of a tank 10 feet square and 10 feet deep, designed with the data contained in tables 3 and 4. The data given in table 3 is an abbreviated form of designating the "Steelcrete" meshes as explained on page 162.

Details

The floor of the tank should be monolithic with the walls and reinforced with "Steelcrete" 3-13-075 bent up into the side walls as shown. The thickness of the base should not be less than 4 inches, and need not be over 6 inches, governed by the thickness of the side walls.

The corners should be filleted as shown. Square inside corners are an element of weakness in reinforced concrete

tanks. The extra cost of the form work required by the method shown will be amply repaid by the additional stability attained.

The ends of sheets should be lapped 8 inches (one diamond) or more. The reinforcement should be continuous around the outer face.

Construction

As in the case of circular tanks, to attain the greatest security against leaking, the concrete should be poured in one operation. The ingredients should be selected carefully, proportioned well and tamped thoroughly.

Special Cases

Where the tank is elevated above the ground, the base must be designed as a floor slab. The services of an engineer should be obtained for this.

As in the case of circular tanks, square tanks depressed in the ground may be designed by the use of the tables. The same amount of reinforcement should be used continuously near the inside face of the side walls that is required near the outside face. There will thus be two layers of reinforcement instead of one.

Rectangular Tanks

When it is desired to design a rectangular tank, proceed as in the case of a square tank, using the longest dimension of the rectangular tank as the side of the square. For example, to design a tank 10 feet by 14 feet and 6 feet in depth, select from tables 3 and 4 the proportions of a tank 14 feet square and construct your tank accordingly. The 10 foot side of tank should be reinforced with the same mesh as the 14 foot side and the walls to be of the same thickness.

"Steelcrete" Mesh

How to Order

In ordering "Steelcrete" mesh, full size sheets should be ordered, the standard sizes of which are given on page 250.

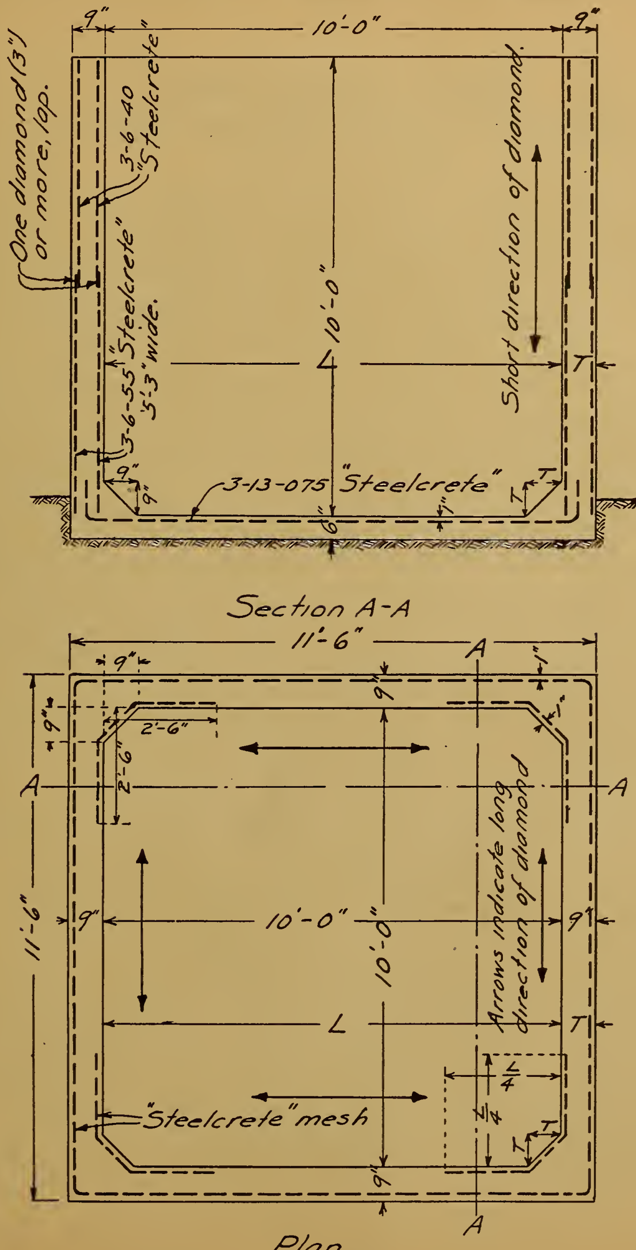

9"
10'-0"
9"
One diamond (3") or more, lap.
3-6-40 "Steelcrete"
3-6-55 "Steelcrete" 5'-3" wide.
10'-0"
L
T
Short direction of diamond.
9"
9"
3-13-075 "Steelcrete"
T
T
6"
1"
Section A-A
11'-6"
A
9"
1"
9"
2'-6"
2'-6"
9"
1"
A
A
11'-6"
9"
10'-0"
10'-0"
9"
Arrows indicate long direction of diamond
L
T
L/4
L/4
T
T
"Steelcrete" mesh
9"
A
Plan

Fig. (11)

Table 1.—Circular Tanks

"Steelcrete" Expanded Metal Mesh required to reinforce the outer vertical wall

Inside depth in feet	Inside diameter in feet at the top											
	5	10	15	20	25	30	35	40	45	50	55	60
5	075	10	15	20	30	30	35	40	45	50	55	55
6	075	$\frac{1}{4}$-075 125	$\frac{1}{4}$-075 20	$\frac{1}{2}$-075 25	30	35	40	45	$\frac{1}{4}$-125 55	$\frac{1}{4}$-15 60	35-35	35-35
7	$\frac{1}{4}$-075 075	15	$\frac{1}{2}$-075 20	30	$\frac{1}{4}$-075 35	40	$\frac{1}{4}$-10 50	$\frac{1}{4}$-15 50	$\frac{1}{2}$-20 60	$\frac{1}{4}$-125 35-35	40-40	40-40
8	$\frac{1}{2}$-075 075	$\frac{1}{4}$-075 15	125 25	$\frac{1}{4}$-075 30	$\frac{1}{4}$-075 40	$\frac{1}{2}$-125 45	25 55	25 60	$\frac{1}{2}$-20 35-35	$\frac{1}{4}$-125 40-40	$\frac{1}{2}$-25 45-45	$\frac{1}{2}$-25 45-45
9	$\frac{1}{2}$-075 10	$\frac{1}{2}$-075 15	$\frac{1}{2}$-075 30	$\frac{1}{2}$-15 35	$\frac{1}{2}$-15 45	25 55	$\frac{1}{4}$-25 25 60	25 35-35	$\frac{1}{2}$-20 40-40	$\frac{1}{2}$-30 45-45	$\frac{1}{2}$-30 50-50	$\frac{1}{2}$-40 50-50
10	075 125	125 20	$\frac{1}{2}$-10 30	$\frac{1}{2}$-15 40	20 50	30 60	25 35-35	25 40-40	25 45-45	50 50-50	45 50-50	35-35 60-60
11	075 125	15 20	125 30	20 45	30 55	40 60	25 40-40	35 45-45	45 50-50	50 50-50	$\frac{1}{2}$-20 60 60-60	
12	$\frac{1}{4}$-075 075 125	$\frac{1}{4}$-075 15 25	15 35	$\frac{1}{2}$-075 25 45	$\frac{1}{4}$-10 35 60	35 35-35	35 40-40	45 45-45	$\frac{1}{4}$-15 55 50-50	$\frac{1}{4}$-15 35-35 60-60		
13	$\frac{1}{2}$-075 075 125	$\frac{1}{2}$-075 15 25	15 40	$\frac{1}{4}$-075 30 50	$\frac{1}{4}$-10 40 60	35 40-40	$\frac{1}{4}$-10 50 45-45	$\frac{1}{2}$-20 55 50-50	25 35-35 60-60			
14	$\frac{1}{4}$-075 075 15	10 20 25	$\frac{1}{2}$-075 20 40	$\frac{1}{2}$-15 35 55	$\frac{1}{4}$-075 40 35-35	40 40-40	20 55 50-50	25 60 50-50				
15	$\frac{1}{2}$-075 075 15	$\frac{1}{4}$-075 15 30	125 25 45	125 40 60	$\frac{1}{2}$-15 45 35-35	$\frac{1}{2}$-15 50 45-45	35 60 50-50	25 40-40 60-60				
16	$\frac{1}{2}$-075 10 15	$\frac{1}{2}$-075 15 30	$\frac{1}{2}$-10 30 45	20 40 60	$\frac{1}{2}$-15 45 40-40	35 60 45-45	35 35-35 50-50					
17	075 15 20	15 20 35	125 30 50	20 45 35-35	20 50 40-40	40 60 50-50	35 40-40 60-60					

Table 1.—Circular Tanks

"Steelcrete" Expanded Metal Mesh required to reinforce the outer vertical wall

Inside depth in feet	Inside diameter in feet at the top. 5	10	15	20	25	30	35	
18	1/2-075 075 125 20	1/2-10 20 25 35	1/2-10 20 35 50	1/2-075 25 45 35-35	1/4-10 35 60 45-45	40 35-35 50-50 —		
19	1/4-075 075 15 20	1/2-075 15 25 35	1/2-075 20 40 55	1/4-075 30 50 35-35	1/2-075 40 60 45-45	1/4-10 40 40-40 60-60		
20	1/2-075 075 15 20	1/2-075 15 25 40	15 25 45 60	1/4-075 30 50 40-40	1/2-125 40 35-35 50-50	25 50 45-45 60-60		
21	1/2-075 10 15 20	10 20 25 40	1/2-10 30 45 60	1/2-15 35 55 40-40	20 45 35-35 50-50			
22	10 15 20 25	1/2-075 15 30 45	15 35 50 60	20 40 60 45-45	20 45 40-40 50-50			
23	1/2-075 075 15 20 25	15 20 35 45 —	15 35 50 35-35 —	20 45 35-35 45-45 —	1/4-075 40 60 45-45 60-60			
24	1/2-075 075 15 20 25	1/2-075 15 25 35 50	1/4-075 20 40 55 35-35	1/2-075 25 45 35-35 45-45	1/2-15 45 60 45-45 60-60			
25	1/2-075 10 15 20 25	075 20 25 40 50	1/2-10 20 40 55 35-35	1/2-075 35 50 35-35 50-50				

Table 2.—Circular Tanks

Total thickness of side walls in inches. 1: 2: 4: concrete

Inside depth in feet	Inside diameter in feet at the top.											
	5'	10	15	20	25	30	35	40	45	50	55	60'
5'	4"	4	4	4	4	4	4	4	5	5	5	6"
6	4	4	4	4	4	4	4	5	5	6	6	7
7	4	4	4	4	4	4	5	5	6	7	7	8
8	4	4	4	4	4	5	5	6	7	8	8	9
9	4	4	4	4	5	5	6	7	8	9	9	10
10	4	4	4	4	5	6	7	8	9	9	10	11
11	4	4	4	4	5	6	7	8	9	10	11	
12	4	4	4	5	6	7	8	9	10	11		
13	4	4	4	5	6	7	9	10	11			
14	4	4	4	5	7	8	9	11				
15	5	5	5	6	7	9	10	11				
16	5	5	5	6	8	9	11					
17	5	5	5	7	8	10	11					
18	5	5	5	7	9	10						
19	5	5	6	7	9	11						
20	5	5	6	8	9	11						
21	5	5	6	8	10							
22	5	5	6	8	10							
23	5	5	7	9	11							
24	5	5	7	9	11							
25	5"	5	7	9								

Thickness of ring at top should not be less than 4".

Table 3.— Square Tanks

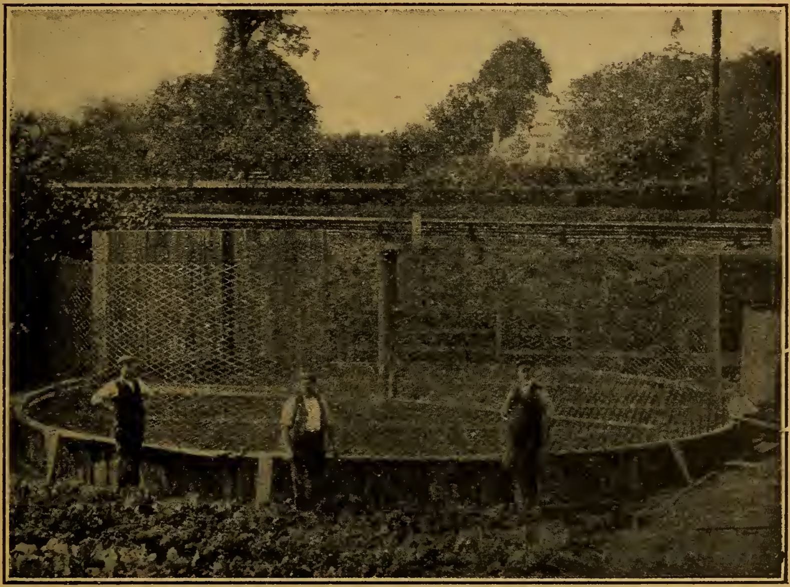
"Steelcrete" Mesh required in the side walls

Inside depth in feet	Inside length in feet: 4	5	6	7	8	9	10	11	12	13	14	15
4	075	125	20	25	25	30	35	35	45	45	50	50
5	10	20	20	30	30	30	35	45	45	55	55	
6	15	¼-075 20	½-10 25	30	35	35	45	45	¼-25 55	¼-25 55		
7	15	½-10 25	½-15 25	30	40	40	¼-15 45	½-25 55	½-25 55			
8	½-075 20	125 25	20 25	½-125 35	¼-10 40	½-20 45	25 50	½-35 55				
9	125 25	½-075 30	½-10 30	25 35	25 45	25 45	½-30 50	35 60				
10	15 25	½-10 30	20 35	20 40	25 45	30 50	40 55					
11	½-075 20 25	125 30	20 35	20 40	35 45	35 55	40 60					
12	½-10 20 25	20 30	30 35	30 45	40 50	40 55						
13		½-075 25 30	½-15 25 35	30 45	¼-10 40 55	½-20 45 60						
14		125 25 35	½-15 25 40	½-125 35 45	25 45 55							
15		½-075 30 35	20 25 40	25 35 45	25 45 55							

Table 4.—Square Tanks

Total thickness of side walls in inches. 1: 2: 4: concrete

Inside depth in feet	Inside length in feet: 4	5	6	7	8	9	10	11	12	13	14	15
4	5	5	5	5	6	6	6	7	7	8	8	9
5	5	5	5	6	6	7	7	7	8	8	9	
6	5	5	5	6	6	7	7	8	8	9		
7	5	5	6	6	7	7	8	8	9			
8	5	5	6	6	7	8	8	9				
9	5	5	6	7	7	8	9	9				
10	5	6	6	7	8	8	9					
11	5	6	6	7	8	8	9					
12	5	6	7	7	8	9						
13		6	7	8	8	9						
14		6	7	8	9							
15		6	7	8	9							



"Steelcrete" Expanded Metal reinforced concrete tank

This illustration shows the tank in course of construction, ready for the forms. Note the stiffness of the sheets, guaranteeing a perfect distribution of the steel.

Highway Bridges and Culverts

Introduction

THE plans and data in the sketches given hereinafter are self-explanatory. Examples are given of the standards adopted by the State and Town Highway Commissions of New York and of the Pennsylvania State Highway Department. Also examples are given of all reinforced concrete culverts, including different designs of wing or head walls, floor systems and other details. This will enable an inquirer to select a design in accordance with his special needs. Attention is called to the quantities of material in most cases given, which have been prepared with painstaking care. These quantities, we believe, will be found of great help in comparing costs.

In New York State and Town Highway Standards, reference is made to 2nd and 3rd class concrete. The following extract from the specifications is explanatory:

"Concrete will be classified as follows: First-class, second-class, third-class.

"First-class concrete shall be made of 1 part Portland cement, 2 parts clean sand or crusher dust, resulting from the breaking of hard trap, hard sandstone, granite or gneiss, and four parts of crushed stone, all measured in loose bulk in boxes or forms of known capacity satisfactory to the engineer.

"Crushed stone for first-class concrete shall be trap, granite or gneiss, satisfactory to the Commission.

"Second-class concrete shall be made of 1 part Portland cement, 2½ parts of clean, approved sand or crusher dust,

and 5 parts of crushed stone or screened washed gravel if permitted by the Engineer, all measured in loose bulk in boxes or forms of known capacity satisfactory to the Engineer.

"Third-class concrete shall be made of 1 part Portland cement, 3 parts clean, approved sand or crusher dust, and 6 parts of crushed stone, all measured in loose bulk as aforesaid."

"Steelcrete" Decimal Standards

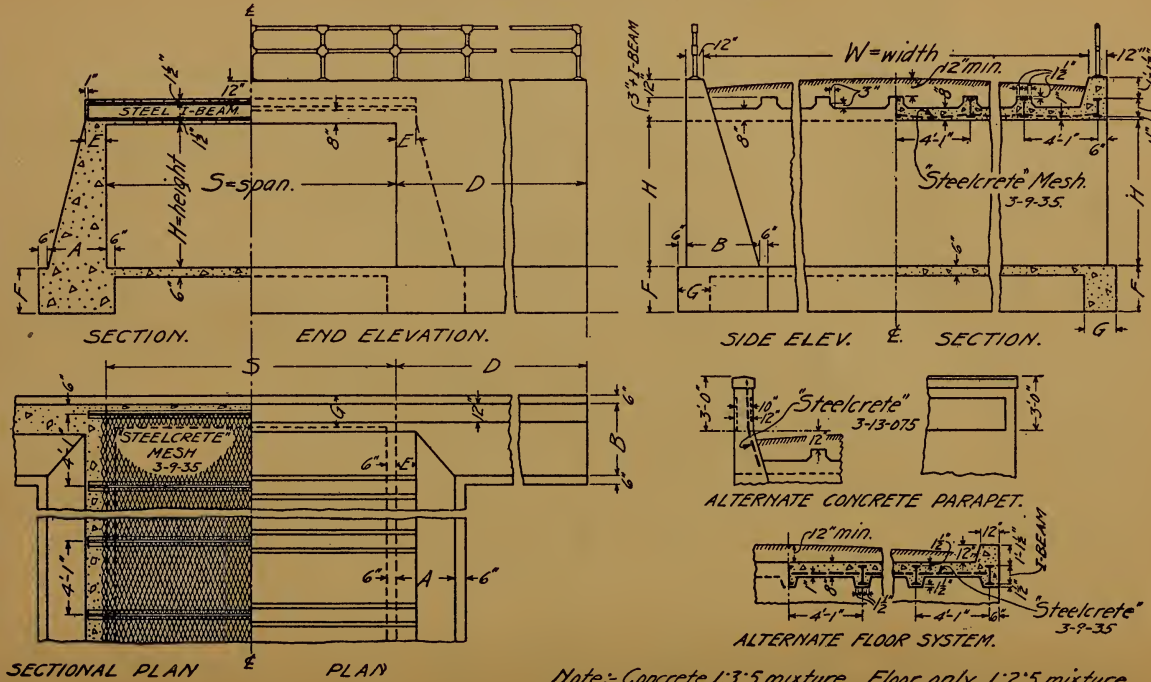
If it is desired to order "Steelcrete" Expanded Metal, the designation of which is only known under the old standards, the following tables will give the corresponding size under the decimal standards at present in vogue.

3″ Meshes

3″ No. 13 Standard	(.28 lbs. per sq. ft.)	Corresponding size 3-13-075
3″ No. 10 Light	(.50 lbs. per sq. ft.)	Corresponding size 3- 9-15
3″ No. 10 Standard	(.60 lbs. per sq. ft,)	Corresponding size 3- 9-175
3″ No. 10 Heavy	(.90 lbs. per sq. ft.)	Corresponding size 3- 9-25
3″ No. 10 Extra Heavy	(1.20 lbs. per sq. ft.)	Corresponding size 3- 9-35
3″ No. 6 Standard	(1.38 lbs. per sq. ft.)	Corresponding size 3- 6-40
3″ No. 6 Heavy	(2.07 lbs. per sq. ft.)	Corresponding size 3- 6-60

HIGHWAY I-BEAM BRIDGES—RIGHT ANGLED WING WALLS.

Maximum load one 15 ton road roller.



Note:—Concrete 1:3:5 mixture. Floor only, 1:2:5 mixture.
Round all exposed edges to a $1\frac{1}{2}$" radius.
Pile foundations to be used in light or shifting soils.
Width W depends upon depth of fill on the top and the width of the roadway.

HIGHWAY I-BEAM BRIDGES–RIGHT ANGLED WING WALLS.

Maximum load one 15 ton road roller.

DIMENSIONS.

H=	A	B	D
4'	2'-0"	2'-9"	9'-0"
6	2'-5"	3'-6"	12'-0"
8	3'-3"	4'-6"	15'-0"
10	4'-0"	5'-3"	18'-0"
12	4'-10"	6'-0"	21'-0"
14	5'-8"	6'-9"	24'-0"
16	6'-5"	7'-6"	27'-0"
18	7'-3"	8'-6"	30'-0"
20'	8'-0"	9'-3"	33'-0"

DIMENSIONS.

SPAN.	E.
8'-0" to 16'-0"	1'-1"
18'-0" to 28'-0"	1'-6"
30'-0" to 38'-0"	2'-0"

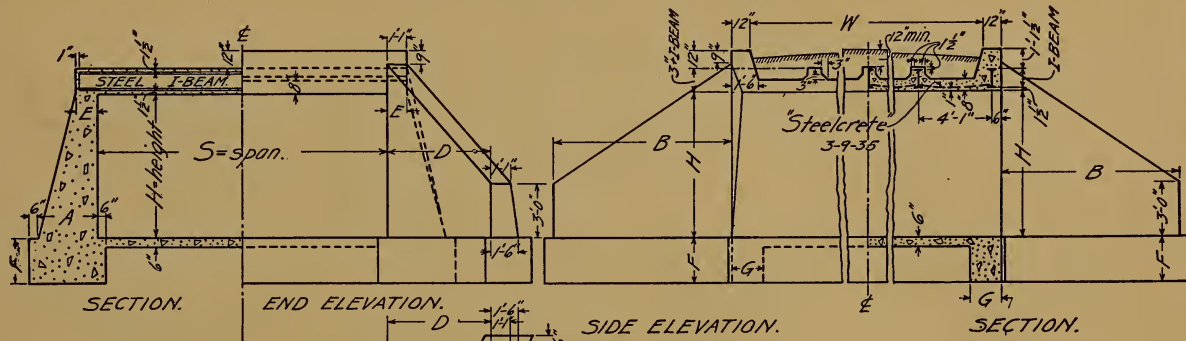
SPAN.	F.
8'-0" to 16'-0"	2'-0"
18'-0" to 28'-0"	2'-6"
30'-0" to 38'-0"	3'-0"

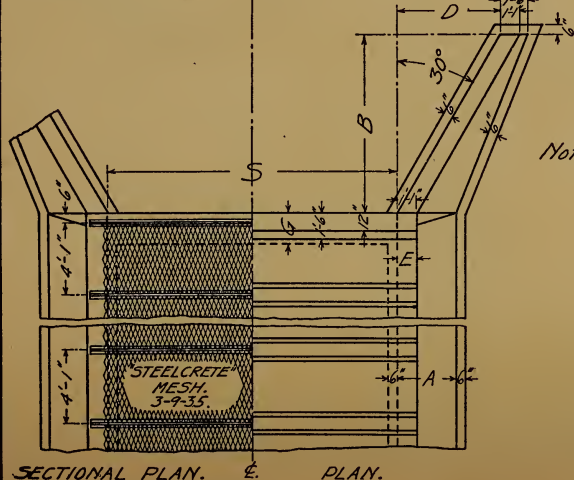
SPAN.	G.
8'-0" to 18'-0"	1'-6"
20'-0" to 38'-0"	2'-0"

S SPAN.	DIMENSIONS. I-BEAMS. NO. FOR W=15'-4"	SIZE	WGT. PER FT.	LENGTH.	QUANTITIES FOR W=15'-4". CUBIC YARDS CONCRETE. 1:3:5 H= 4'	6	8	10	12	14	16	18	20'	1:2:5	"STEELCRETE." 3-9-35. NO. OF SHEETS	STAND. SIZE	TOTAL SQ. FT.	LBS. I-BEAMS.
8'	5	10"	25#	10'-0"	40	67	110							6	3	6'-0" wide by 8'-0" long.	144	1250
10'	"	12"	31½#	12'-0"	41	68	111	164						8	4		192	1890
12'	"	12"	35#	14'-0"	42	69	112	165	233					9	4		192	2450
14'	"	12"	40#	16'-0"	43	70	113	166	234	319				10	5		240	3200
16'	"	15"	42#	18'-0"	45	72	115	168	236	321	422			13	6		288	3780
18'	"	15"	45#	20'-10"	51	80	125	182	252	340	444	580		14	6		288	4687
20'	"	15"	50#	22'-10"	54	83	128	184	254	342	446	582	730	16	7		336	5707
22'	"	18"	60#	24'-10"	56	86	132	188	259	347	453	589	738	18	8		384	7449
24'	"	18"	65#	26'-10"	57	87	133	189	260	348	454	590	739	20	8		384	8720
26'	"	18"	70#	28'-10"	58	88	134	190	261	349	455	591	740	21	9		432	10090
28'	"	20"	70#	30'-10"	60	90	135	192	264	352	458	594	744	24	10		480	10790
30'	"	20"	75#	33'-10"	68	99	148	207	282	372	481	622	775	26	10		480	12686
32'	"	24"	85#	35'-10"	70	102	151	211	286	377	489	630	785	30	11		528	15228
34'	"	24"	90#	37'-10"	72	104	153	213	288	379	491	632	786	32	12		576	17023
36'	"	24"	95#	39'-10"	73	105	154	214	290	381	492	633	787	33	12		576	18919
38'	"	24"	100#	41'-10"	74	106	155	215	291	382	493	634	788	35	13		624	20915

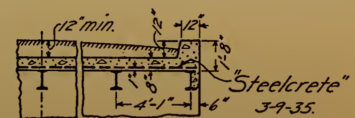
HIGHWAY I-BEAM BRIDGES—SKEWED WING WALLS.

Maximum load one 15 ton road roller.





Note:—Concrete 1:3:5 mixture. Floor only, 1:2:5 mixture.
Round all exposed edges to a 1½" radius.
Pile foundations to be used in light or shifting soils.
Width W depends upon depth of fill on the top and the width of the roadway.
Alternate floor system and concrete parapet may be used as given with RIGHT ANGLED WING WALLS.



ALTERNATE FLOOR SYSTEM.
May also be used with RIGHT ANGLED WING WALLS.

HIGHWAY I-BEAM BRIDGES—SKEWED WING WALLS.

Maximum load one 15 ton road roller.

DIMENSIONS.

H=	A	B	D
4'	2'-0"	5'-3"	3'-0"
6	2'-5"	8'-3"	4'-9"
8	3'-3"	11'-3"	6'-6"
10	4'-0"	14'-3"	8'-3"
12	4'-10"	17'-3"	10'-0"
14	5'-8"	20'-3"	11'-9"
16	6'-5"	23'-3"	13'-5"
18	7'-3"	26'-3"	15'-2"
20'	8'-0"	29'-3"	16'-10"

DIMENSIONS.

SPAN.	E.
8'-0" to 16'-0"	1'-1"
18'-0" to 28'-0"	1'-6"
30'-0" to 38'-0"	2'-0"

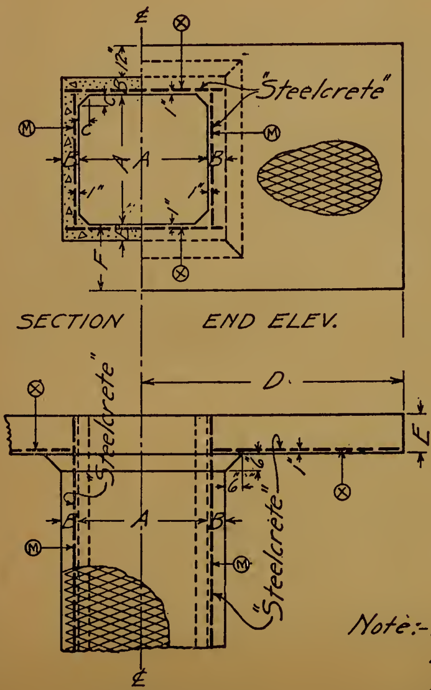
SPAN.	F.
8'-0" to 16'-0"	2'-0"
18'-0" to 28'-0"	2'-6"
30'-0" to 38'-0"	3'-0"

SPAN.	G
8'-0" to 18'-0"	1'-6"
20'-0" to 38'-0"	2'-0"

S SPAN.	DIMENSIONS. I-BEAMS. NO. FOR W=15'-4"	SIZE	WGT. PER FT.	LENGTH	QUANTITIES FOR W=15'-4". CUBIC YARDS CONCRETE. 1:3:5 H= 4'	6	8	10	12	14	16	18	20'	1:2:5	"STEELCRETE." 3-9-35. NO. OF SHEETS	STAND. SIZE.	TOTAL SQ. FT.	LBS. I-BEAMS.
8'	5	10"	25#	10'-0"	29	44	67							6	3	6'-0" wide by 8'-0" long.	144	1250
10'	"	12"	31½#	12'-0"	30	45	68	98						8	4		192	1890
12'	"	12"	35#	14'-0"	31	46	69	99	137					9	4		192	2450
14'	"	12"	40#	16'-0"	32	47	70	100	138	184				10	5		240	3200
16'	"	15"	42#	18'-0"	33	48	72	102	139	186	239			13	6		288	3780
18'	"	15"	45#	20'-10"	39	56	81	113	154	203	259	326		14	6		288	4687
20'	"	15"	50#	22'-10"	42	58	84	116	156	205	261	329	405	16	7		336	5707
22'	"	18"	60#	24'-10"	43	60	85	117	158	207	264	331	408	18	8		384	7449
24'	"	18"	65#	26'-10"	44	61	87	119	160	209	265	333	409	20	8		384	8720
26'	"	18"	70#	28'-10"	45	62	88	120	161	210	266	334	410	21	9		432	10090
28'	"	20"	70#	30'-10"	47	64	90	121	163	212	268	336	413	24	10		480	10790
30'	"	20"	75#	33'-10"	54	73	101	135	179	231	290	366	441	26	10		480	12686
32'	"	24"	85#	35'-10"	56	75	103	138	181	234	293	370	444	30	11		528	15228
34'	"	24"	90#	37'-10"	57	76	104	139	183	235	295	371	446	32	12		576	17023
36'	"	24"	95#	39'-10"	59	77	106	140	184	237	296	372	447	33	12		576	18919
38'	"	24"	100#	41'-10"	60	79	107	142	185	238	297	374	449	35	13		624	20915

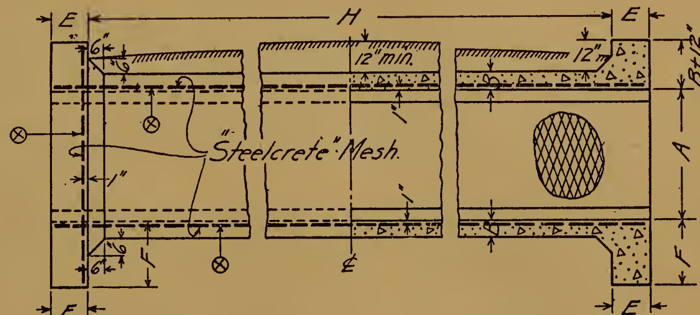
HIGHWAY BOX CULVERTS.

Maximum load 15 ton road roller.



SECTION   END ELEV.

PLAN.



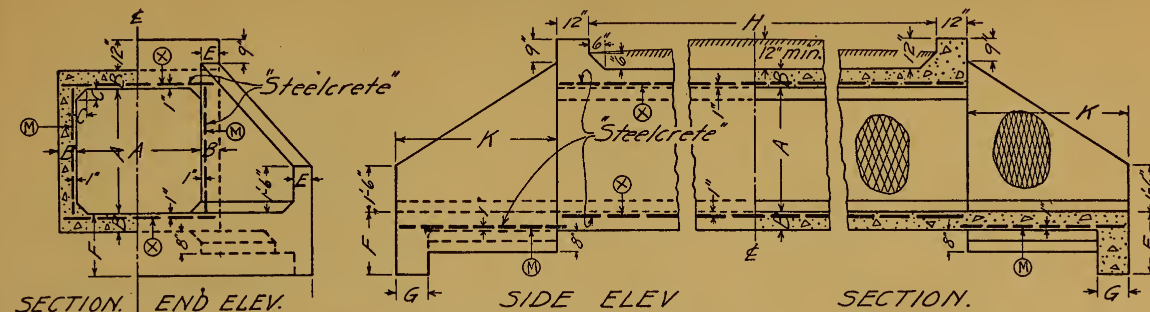
SIDE ELEV.   SECTION.

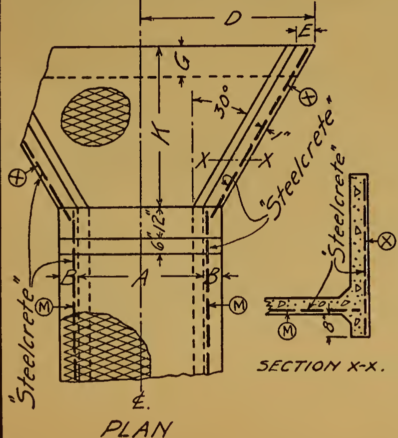
DIMENSIONS.								QUANTITIES FOR H=16'-0"			
								"STEELCRETE"			CU. YDS. CONCRETE 1:2:5
SIZE.	A	B	C	D	E	F	"STEELCRETE" MESH.	NO. OF SHEETS	STAND. SIZE	TOTAL SQ. FT.	
2'x2'	2'-0"	6"	3"	4'-0"	6"	1'-6"	Ⓜ 3-13-10 ⊗ 3-9-30	1 3	6'-9"x12' 7'-0"x10'	81 210	4½
3'x3'	3'-0"	7"	3"	6'-0"	8"	1'-9"	Ⓜ 3-13-125 ⊗ 3-9-35	2 4	5'-3"x12' 6'-0"x12'	126 288	8½
4'x4'	4'-0"	8"	4"	8'-0"	12"	2'-0"	Ⓜ 3-9-15 ⊗ 3-6-40	2 5	7'-0"x12' 7'-0"x12'	168 420	15¾

Note:- All concrete 1:2:5 mixture.
Round all exposed edges to a 1½" radius.
Pile foundations to be used in light or shifting soils.
Distance H depends upon depth of fill on the top and the width of the roadway.

HIGHWAY BOX CULVERTS.

Maximum load 15 ton road roller.



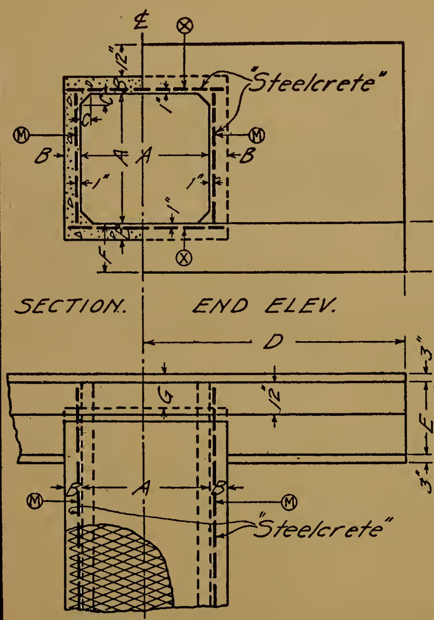


DIMENSIONS.										QUANTITIES FOR H=16'-0".			
										"STEELCRETE"			CU. YDS. CONCRETE. 1:2:5
SIZE.	A	B	C	D	E	F	G	K	"STEELCRETE" MESH.	NO. OF SHEETS	STAND. SIZE.	TOTAL SQ. FT.	
4'x4'	4'-0"	8"	4"	5'-8"	8"	2'-0"	1'-0"	5'-2"	Ⓜ 3-9-15 ⊗ 3-6-40	4 5	7'-0"x12' 7'-0"x12'	336 420	$14\frac{1}{2}$
5'x5'	5'-0"	9"	5"	7'-2"	9"	2'-0"	1'-0"	6'-9"	Ⓜ 3-9-15 ⊗ 3-6-45	5 7	7'-0"x10' 6'-3"x12'	350 525	21
6'x6'	6'-0"	10"	6"	8'-8"	10"	2'-0"	1'-0"	8'-5"	Ⓜ 3-9-20 ⊗ 3-6-50	8 13	5'-3"x12' 5'-9"x8'	504 598	$29\frac{1}{2}$
7'x7'	7'-0"	11"	7"	10'-3"	11"	2'-3"	1'-3"	10'-0"	Ⓜ 3-9-20 ⊗ 3-6-55	15 17	5'-3"x8' 5'-3"x8'	630 714	41
8'x8'	8'-0"	12"	8"	11'-9"	12"	2'-3"	1'-3"	11'-8"	Ⓜ 3-9-20 ⊗ 3-6-60	17 17	5'-3"x8' 4'-9"x12'	714 969	53

Note:- All concrete 1:2:5 mixture.
Round all exposed edges to a $1\frac{1}{2}$" radius.
Pile foundations to be used in light or shifting soils.
Distance H depends upon depth of fill on the top and the width of the roadway.

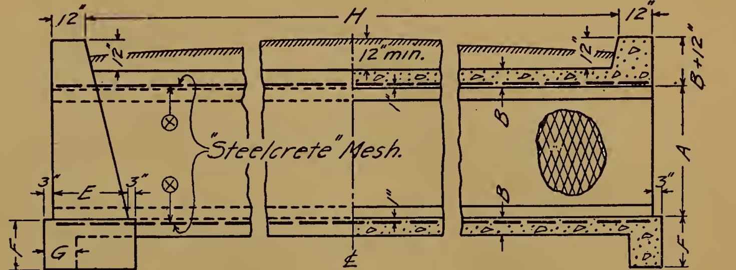
HIGHWAY BOX CULVERTS.

Maximum load 15 ton road roller.



SECTION. END ELEV.

PLAN.

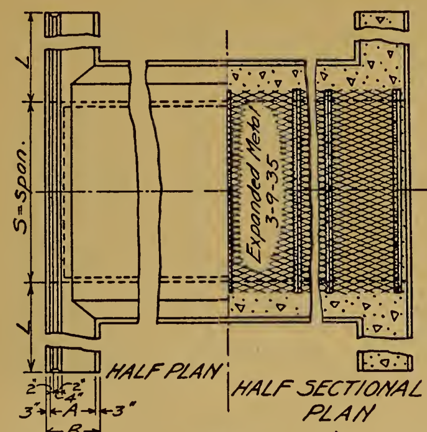


SIDE ELEV. SECTION.

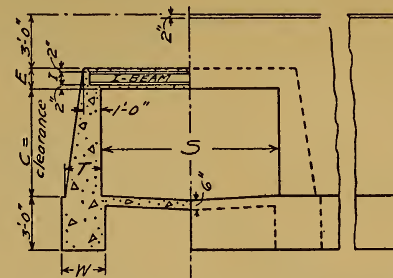
DIMENSIONS.									QUANTITIES FOR H=16'-0".					
									"STEELCRETE"			CU. YDS. CONCRETE.		
SIZE.	A	B	C	D	E	F	G	"STEELCRETE" MESH.	NO. OF SHEETS.	STAND. SIZE.	TOTAL SQ. FT.	1:2:5	1:3:5	TOTAL
2'×2'	2'-0"	6"	3"	4'-0"	1'-6"	1'-0"	9"	Ⓜ 3-13-10 ⊗ 3-9-30	1 2	6'-9"×12' 7'-0"×16'	81 140	$3\frac{3}{4}$	$2\frac{1}{2}$	$6\frac{1}{4}$
3'×3'	3'-0"	7"	3"	6'-0"	1'-10"	1'-0"	9"	Ⓜ 3-13-125 ⊗ 3-9-35	2 4	5'-3"×12' 6'-0"×8'	126 192	6	$5\frac{1}{4}$	$11\frac{1}{4}$
4'×4'	4'-0"	8"	4"	8'-0"	2'-3"	1'-6"	1'-0"	Ⓜ 3-9-15 ⊗ 3-6-40	2 3	7'-0"×12' 7'-0"×12'	168 252	9	11	20
5'×5'	5'-0"	9"	5"	10'-0"	2'-9"	1'-6"	1'-0"	Ⓜ 3-9-15 ⊗ 3-6-45	3 3	7'-0"×10' 6'-3"×12'	210 225	$12\frac{1}{4}$	18	$30\frac{1}{4}$
6'×6'	6'-0"	10"	6"	12'-0"	3'-1"	1'-6"	1'-0"	Ⓜ 3-9-20 ⊗ 3-6-50	4 7	5'-3"×12' 5'-9"×8'	252 322	$16\frac{1}{4}$	$26\frac{1}{4}$	$42\frac{1}{2}$
7'×7'	7'-0"	11"	7"	14'-0"	3'-6"	2'-0"	1'-6"	Ⓜ 3-9-20 ⊗ 3-6-55	7 7	5'-3"×8' 5'-3"×8'	294 294	$20\frac{1}{2}$	41	$61\frac{1}{2}$
8'×8'	8'-0"	12"	8"	16'-0"	4'-0"	2'-0"	1'-6"	Ⓜ 3-9-20 ⊗ 3-6-60	7 8	5'-3"×8' 4'-9"×12'	294 456	$25\frac{1}{2}$	$56\frac{1}{2}$	82

Note:— Box 1:2:5 mixture. End walls may be 1:3:5 mixture.
Round all exposed edges to a $1\frac{1}{2}$" radius.
Pile foundations to be used in light or shifting soils.
Distance H depends upon depth of fill on the top and the width of the roadway.

PENNSYLVANIA STATE HIGHWAYS
CONCRETE I-BEAM BRIDGES.
1910.

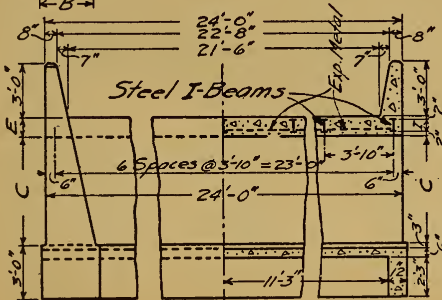


HALF PLAN. HALF SECTIONAL PLAN



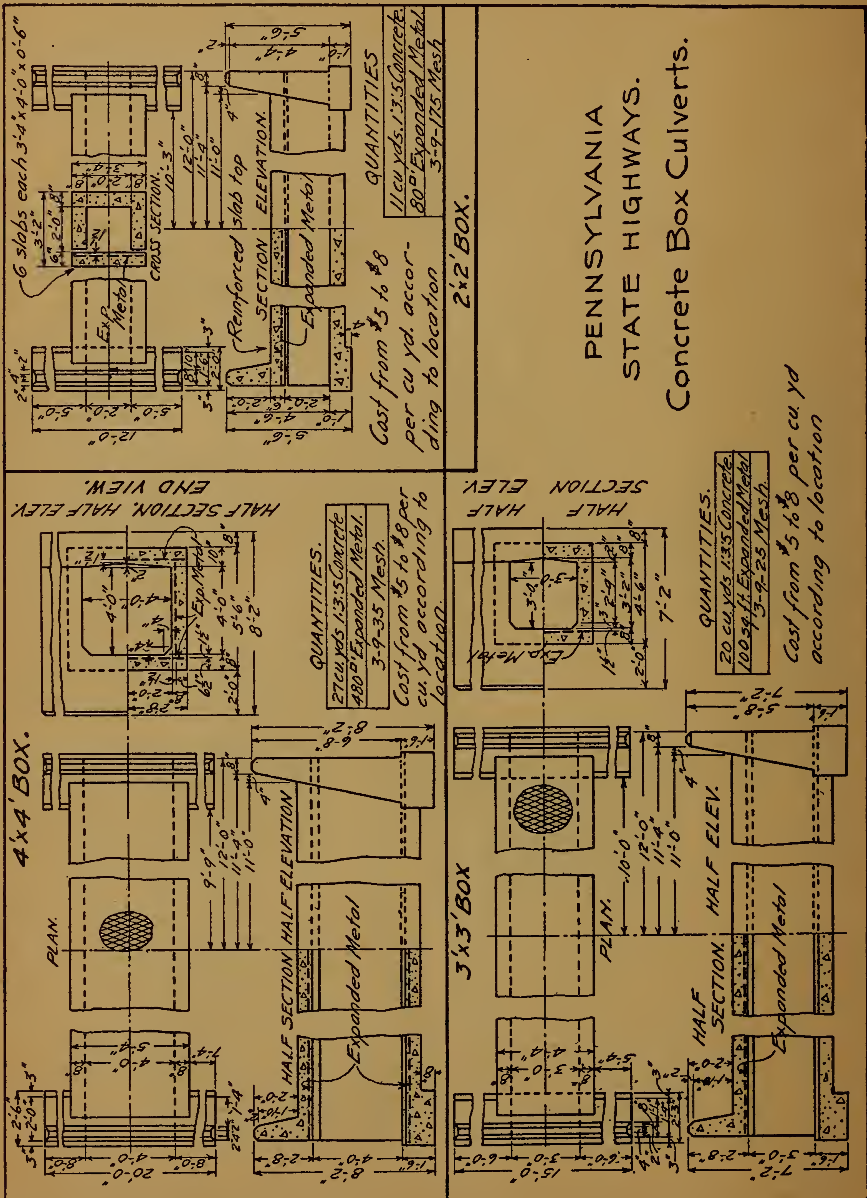
HALF SECTION. HALF ELEVATION.

Approx. cost of 8'x4' Bridge = from $300 to $500
" " " 12'x6' " " " $575 " $875



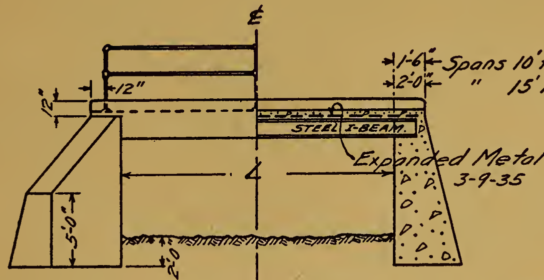
HALF ELEV. HALF SECTION.

DIMENSIONS.											QUANTITIES.		
Span Clearance. S C	W	T	E	B	A	L	I-BEAMS. Number.	I Size.	Wt. per Ft.	Length	Cu. Yds. 1:3:5 Concrete.	Pounds I-Beams.	Sq. Ft. Exp. Metal. 3-9-35
8'x4'	2'-3"	1'-9"	12"	2'-9"	2'-3"	8'	7	8"	18#	9'-4"	53	1176	215
10'x4'	"	"	13"	"	"	"	7	9"	21#	11'-4"	57	1666	305
12'x4'	"	"	14"	"	"	"	7	10"	25#	13'-4"	62	2333	360
8'x6'	2'-6"	2'-0"	12"	3'-0"	2'-6"	10'	7	8"	18#	9'-4"	70	1176	215
10'x6'	"	"	13"	"	"	"	7	9"	21#	11'-4"	84	1666	305
12'x6'	"	"	14"	"	"	"	7	10"	25#	13'-4"	90	2333	360


PENNSYLVANIA
STATE HIGHWAYS.
Concrete Box Culverts.
4'x4' BOX.
PLAN.
HALF SECTION HALF ELEVATION
HALF SECTION. HALF ELEV.
END VIEW.
Expanded Metal
Exp. Metal
QUANTITIES.
27 cu. yds 1:3:5 Concrete
480# Expanded Metal.
3-9-35 Mesh.
Cost from $5 to $8 per cu. yd according to location.
2'x2' BOX.
6 slabs each 3'-4"x4'-0"x0'-6"
CROSS SECTION.
Reinforced slab top
SECTION ELEVATION.
Expanded Metal
Exp. Metal
QUANTITIES
11 cu yds. 1:3:5 Concrete
80# Expanded Metal
3-9-175 Mesh
Cost from $5 to $8 per cu yd. according to location
3'x3' BOX
PLAN.
HALF SECTION. HALF ELEV.
HALF SECTION HALF ELEV.
Expanded Metal
Exp. Metal
QUANTITIES.
20 cu. yds 1:3:5 Concrete
100 sq. ft. Expanded Metal
3-9-25 Mesh.
Cost from $5 to $8 per cu. yd according to location

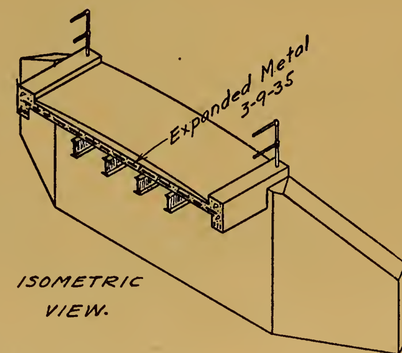
STATE OF NEW YORK—TOWN HIGHWAYS.

CONCRETE I-BEAM BRIDGES.

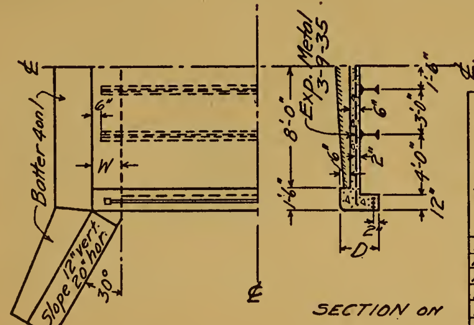


ELEVATION

SECTION ON ℄ ROADWAY.



ISOMETRIC VIEW.



PART PLAN

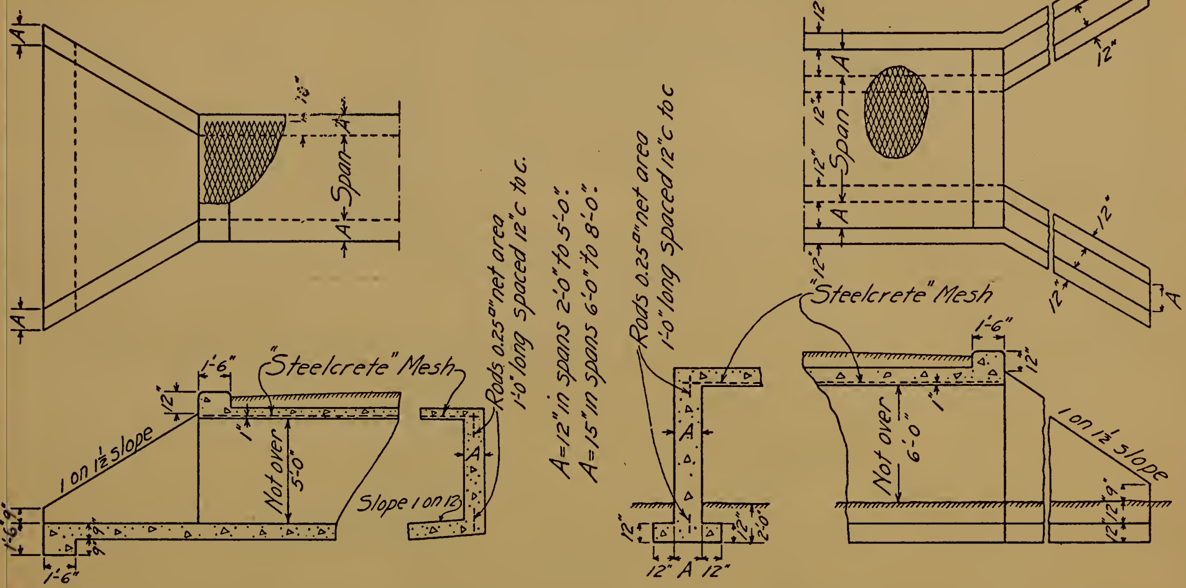
SECTION ON ℄ BRIDGE.

Concrete 1:2½:5 mixture.

Load = 10 ton road roller.

Clear Span.	Size of I-Beams	Size of Rods.	D.	Weight. Rods Lbs.	Weight. I Beams Lbs.	Expanded Metal Sq. Ft.	CONCRETE CU. YDS. IN FLOOR ONLY.
10'	12"-31½#×12'-0"	0.39□"×12'-6"	2'-3"	105	1512	260	6.62
12'	" " ×14'-0"	0.56□"×15'-0"	2'-3"	181	1764	300	7.64
14'	" " ×16'-0"	0.77□"×17'-6"	2'-3"	287	2016	340	8.66
16'	15"-42#×19'-0"	" ×19'-6"	2'-6"	319	3192	400	10.56
18'	" " ×21'-0"	1.00□"×22'-0"	2'-6"	473	3528	440	11.61
20'	" " ×23'-0"	" ×24'-0"	2'-6"	515	3864	470	12.67
22'	18"-55#×25'-0"	" ×26'-0"	2'-9"	537	5500	510	14.20
24'	" " ×27'-0"	1.56□"×28'-7"	2'-9"	959	5940	550	15.30
26'	" " ×29'-0"	" ×30'-7"	2'-9"	1024	6380	590	16.40
28'	20"-65#×31'-0"	" ×32'-8"	2'-11"	1094	8060	630	17.89
30'	" " ×33'-0"	" ×34'-8"	2'-11"	1163	8580	670	19.00

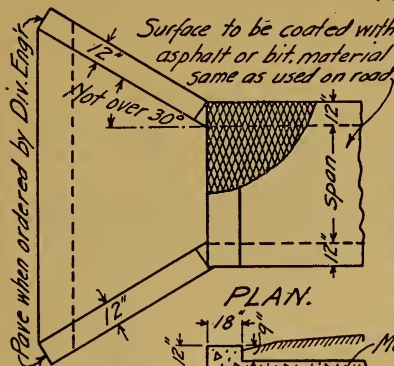
STATE OF NEW YORK–TOWN HIGHWAYS.
STANDARD CULVERTS.



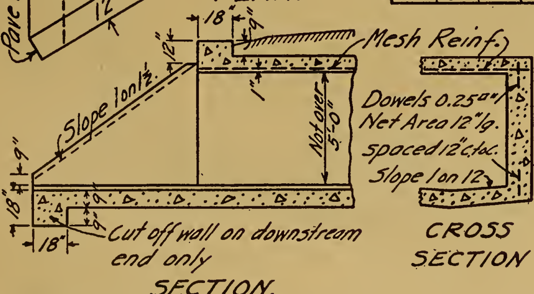
Note:- Round all exposed edges to a 1½" radius.
2nd class concrete in slabs.
3rd class concrete in wing walls & abutments.
Water way to be paved when in the judgment of the County Engineer, paving is necessary.
Pile foundations to be used in light or shifting soils.

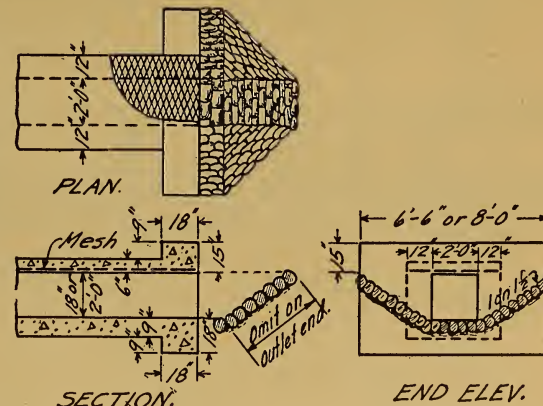
Span	Thickness of slab	"Steelcrete" Mesh Designation	"Steelcrete" Mesh wgt per sq ft
2'-0"	6"	3-9-175	0.64*
3'-0"	6"	3-9-35	1.28
4'-0"	6"	3-9-35	1.28
5'-0"	8"	3-9-35	1.28
6'-0"	9"	3-6-60	2.19
7'-0"	10"	3-6-60	2.19
8'-0"	12"	3-6-60	2.19

STATE OF NEW YORK
Standard Concrete Culverts.
FOR STATE AND COUNTY HIGHWAYS.

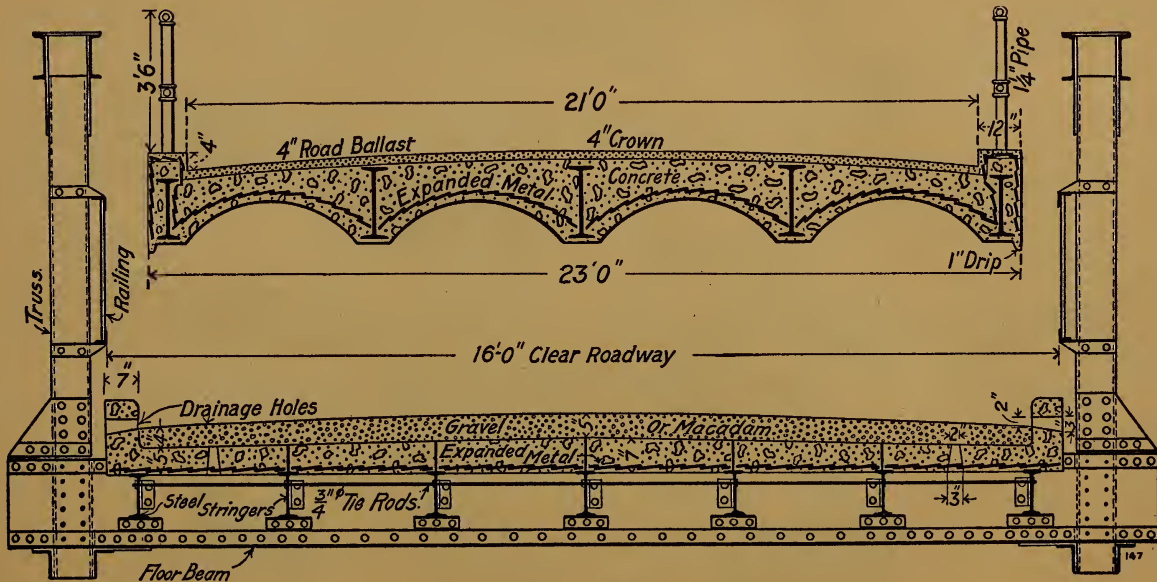


DIMENSIONS FOR HEIGHTS 18" to 5'-0"			
SPAN.	THICKNESS OF SLAB.	MESH REINF. LBS. PER SQ. FT.	EXPANDED METAL.
2'-0"	6"	0.6	3-9-17.5
3'-0"	6"	1.2	3-9-35
4'-0"	6"	1.2	3-9-35
5'-0"	8"	1.2	3-9-35





Note:- All mesh reinforcement to be of medium steel.
All slabs and parapets to be of 2nd class concrete.
All wings, inverts and abutments to be of 3rd class concrete.
Wings on outlet end of all square culverts with concrete floors to be built parallel to the center line of the culvert.
All exposed edges to be rounded to a 1½" radius.



Bridge Floors

The style of floor shown in the lower figure has been adopted as a standard by the State of New York, as it is cheaper in the long run than plank

Reinforced Concrete Retaining Walls

Comparative Types

LITTLE need be said of the economy of the reinforced over the non-reinforced type of retaining walls. Suffice it to say a total saving of 25 per cent to 45 per cent has been reached in railroad and municipal work by the adoption of the steel reinforced type. The somewhat technical features entering into the design of the reinforced type of retaining walls, coupled with the lack of standardized designs, has served to retard its universal adoption.

Reinforced Types

In standardizing the two common types of reinforced retaining walls, namely, the "cantilever" and the "counterfort," this chapter, in the accompanying designs and data, will be found to fill a long felt want. The quantities of material also included in the tables will facilitate greatly the estimating of costs. The designs herewith submitted will be found to conform with the best standard practice. According to authorities cantilever types are more economical than the counterfort, up to a height of 16 to 20 feet. The quantities given will enable anyone to arrive at the most economical construction for his particular case. An allowance should be made for the increased labor on form work in the counterfort type of retaining walls.

Foundation

No wall should be built on a foundation of soil of less bearing power than three tons per square foot, and wherever possible the wall should be built on rock. If a clay foundation must be resorted to, it is very important that it be kept dry and below the frost line. When troubled with springs or accumulative

surface water, provide trenches every ten feet to drain the water from the foundation. Such trenches may be one foot width and depth, and filled with coarse gravel well compacted and given sufficient slope to insure run off.

Baker's Table of safe bearing power of soils gives the following permissible loads:

	Tons per sq. ft.
Rock equal to best ashlar	25 to 30
Rock equal to best brick masonry	15 to 20
Rock equal to poor brick masonry	5 to 10
Clay — dry thick beds	4 to 6
Clay — Moderately dry thick beds	2 to 4
Clay — Soft	1 to 2
Gravel and coarse sand well cemented	8 to 10
Sand — Compact and well cemented	4 to 6
Sand — Clean and dry	2 to 4
Quick sand, alluvial soil, etc.	½ to 1

The Key

There are three phases of wall failure, viz.: overturning, crushing and sliding. The first two have been properly cared for in the designs shown. The third depends more or less on the nature of the soil which is taken for the foundation. A wall built on solid rock does not necessarily have to be keyed, but the surface of the rock should be roughened. In all other soils a key is absolutely necessary to keep the wall from sliding and throwing the wall out of alignment. The key is shown on all designs, Plates I, II, III, and IV. The key is that small portion of the wall which projects downward from the base at about its center.

Concrete

Proportion 1: 2: 4.

Expansion Joints

If it is desired to guard strongly against seepage of water through cracks which may result from temperature changes, expansion joints should be provided at intervals of thirty feet which extend from the foundation bed through the coping.

Water may be prevented from seeping through these joints by forming a rectangular vertical recess in the wall as it is built up, which is filled and well rammed with plastic clay. Authorities differ on the subject of expansion joints. In many instances cases may be cited where expansion joints have been left out, and the work found perfectly satisfactory.

Sufficient steel has been allowed in the designs hereinafter submitted to take care of temperature stresses according to theoretical and common practice. It should be remembered that there is a big distinction between surface hair cracks and deep cracks permitting seepage.

Waterproofing

A concrete mixture so proportioned as to give the maximum density has been demonstrated to be satisfactorily waterproof. If it is deemed advisable, however, any good waterproofing compound may be added.

Surface Finish

Many methods of finishing concrete surfaces are in vogue. Some are as follows:

- Cement washing or grouting
- Rubbing up
- Tooling
- Sand Blasting
- Plastering

It has been found more satisfactory and economical to decide which surface finish is desired before the work is started so that the surface may be treated immediately after the forms are taken down and while the concrete is green. On plastered surfaces, the rough or unfinished side of the board should be next to the wall. This gives a rough surface and aids the plaster in adhering to the wall. Boards of unequal thickness should be avoided in forms in which a surface finish is desired.

Back Fill

All coarse material, such as broken stone or unused gravel, should be placed in back of wall. A volume of at least one-half

cubic yard of such material should be placed at the inside end of the drains, so that they will not become stopped up with earth. Space drains of three-inch diameter five feet on centers, and place them at such a height from the surface of the ground that a free discharge of the water back of the wall will be allowed. Supplying the wall with drains aids waterproofing and serves as a precautionary method of eliminating the hydrostatic head which may form back of the wall.

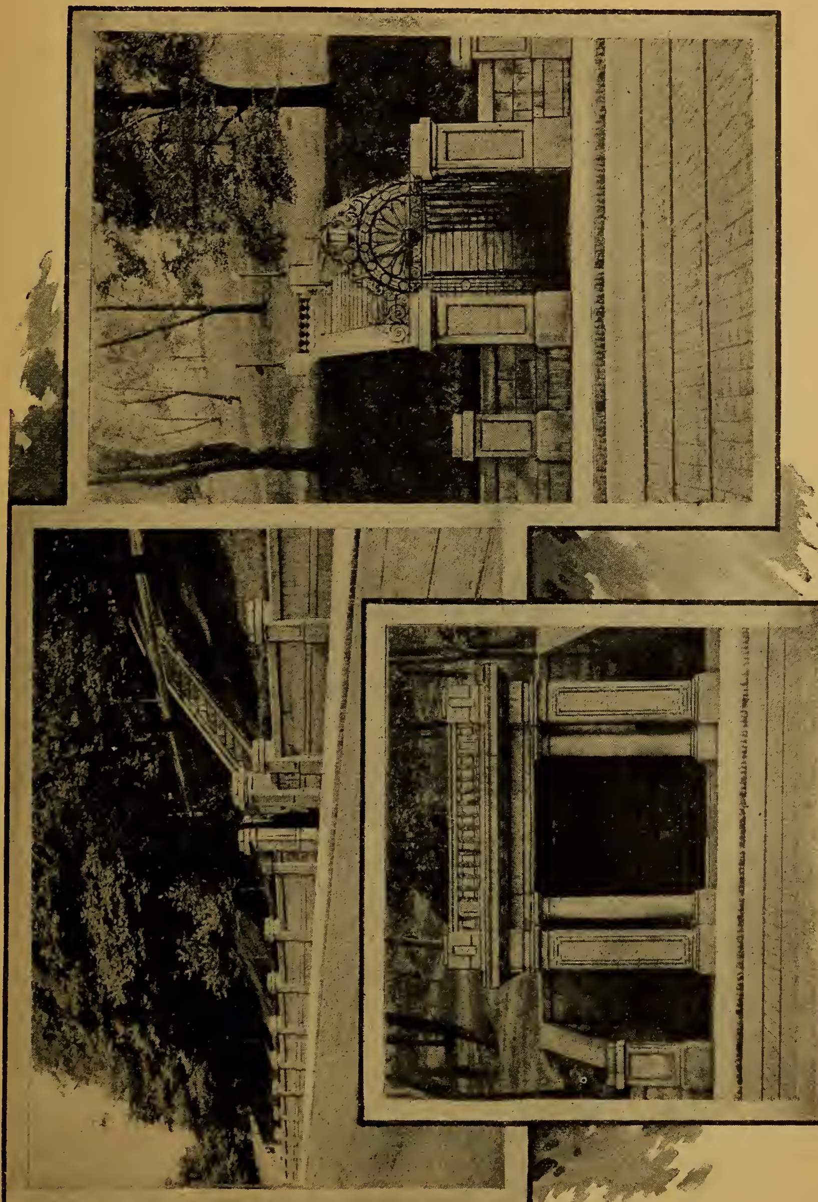
The following notes are to be used in connection with Plates I, II, III, and IV.

Spacing of Horizontal Tie Rods

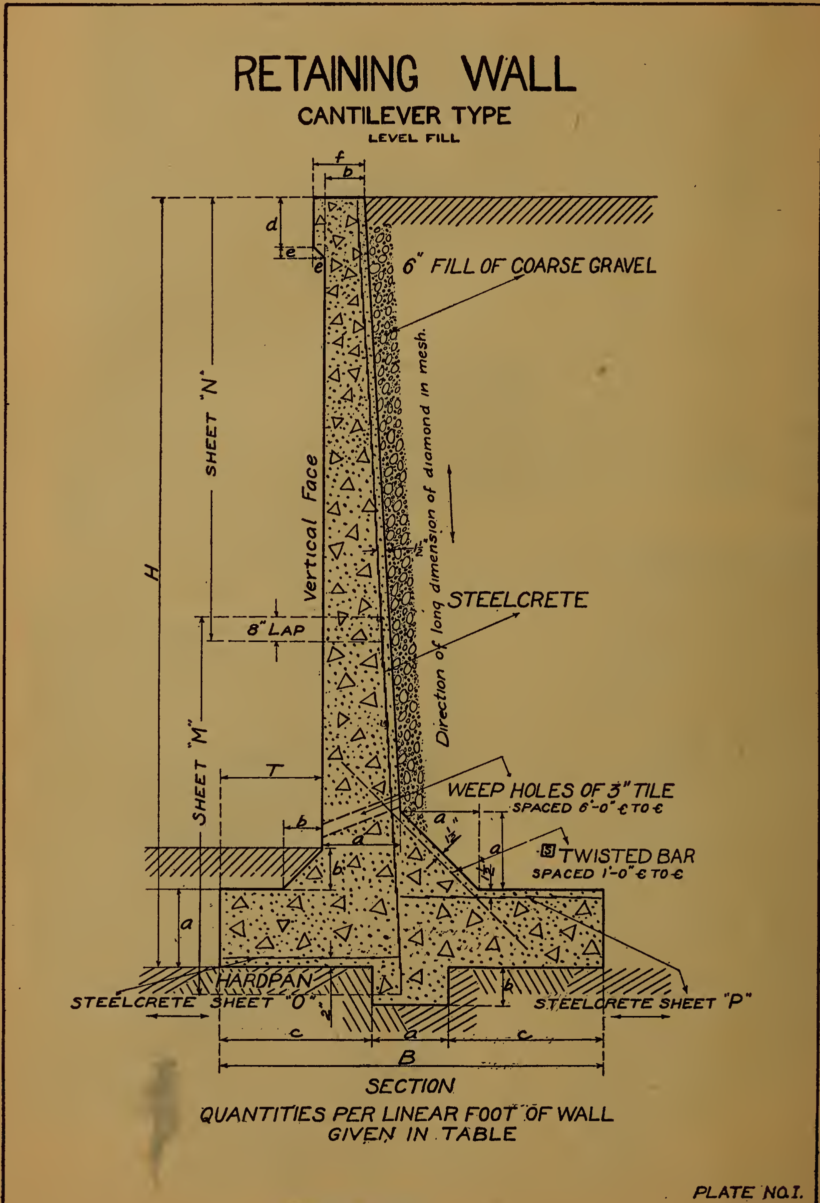
The spacing shown on line 'M' Plate IV is given for a wall of 25 foot height, (H = 25′–0″). For any wall of less height the spacing applies as given, to be read from the top, omitting whatever rods may not be included. Example: The spacing of these horizontal rods for an 18 ft. wall (H = 18′–0″) would be as follows, reading downward from the top: 2′ 0″, 2′ 0″, 1′ 6″, 1′ 3″. Three spaces at 1′ 0″, seven spaces at 9″ and two spaces at 6″, the remaining rods of the sketch being omitted. The sum of the above spaces equal 16′ 0″. The bottom slab is 1′-10″ according to the tables; therefore, 16′ 0″ plus 1′ 10″ equals 17′ 10″ or the last horizontal tie rod is 2″ above the bottom slab of the wall.

Note on "Steelcrete" for Counterfort Type

Sheets extend continuously across the front face of the counterfort type as indicated in section X Y of Plate IV, Sheets 6′ 0″ total length of the same size as in front to be placed on back of face wall at the counterforts. This is also indicated in the same section. The direction of the diamonds in all the mesh in the face wall is given in the rear elevation of Plate IV. All sheets should be lapped the length of one diamond (8″) on the ends to insure continuity, and the width of one diamond (3″) on the sides. Wherever two or more sheets are required a spacing of one-inch should be allowed between sheets to insure a good bond in the concrete.



Famous Howe Springs fronting the residence of M. L. Benedum, Fifth and Highland Avenues, Pittsburgh, Pa. Retaining Wall reinforced with "Steelcrete" Mesh throughout. Surface finish imitation cut stone. W. H. Van Tine, landscape architect and designer



RETAINING WALL
CANTILEVER TYPE
LEVEL FILL
6" FILL OF COARSE GRAVEL
SHEET "N"
SHEET "M"
Vertical Face
Direction of long dimension of diamond in mesh.
STEELCRETE
8" LAP
WEEP HOLES OF 3" TILE
SPACED 6'-0" ℄ TO ℄
TWISTED BAR
SPACED 1'-0" ℄ TO ℄
HARDPAN
STEELCRETE SHEET "O"
STEELCRETE SHEET "P"
H
SECTION
QUANTITIES PER LINEAR FOOT OF WALL
GIVEN IN TABLE
PLATE NO.I.

RETAINING WALL

CANTILEVER TYPE

LEVEL FILL

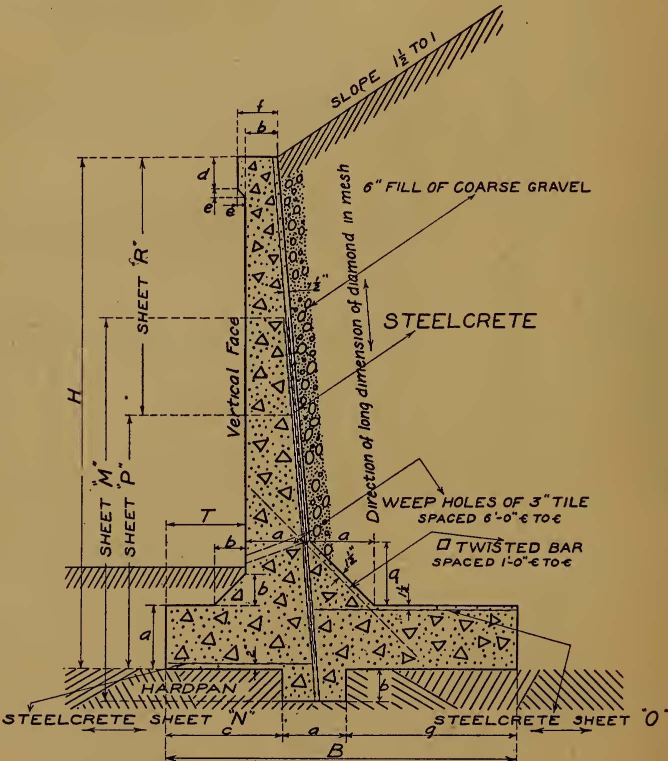
Table in connection with PLATE No. I

DIMENSIONS									STEELCRETE — Size of mesh and Sq. Ft. required per lin. ft. of Wall				Size of Bars	QUANTITIES per Lin. Ft. of Wall.	
Height	Base								sheets						
H	B	T	a	b	c	d	e	f	M	O	P	N	1 Ft. C to C	Concrete Cu. Yds.	Bars Lbs.
6'	3'-0"	0'-10"	0'-7"	0'-6"	1'-2½"	1'-0"	3"	0'-9"	3-9-15 6.00	3-13-075 1.33	3-13-075 1.33		¼"	0.20	0.53
7'	3'-6"	0'-11"	0'-8½"	0'-6"	1'-4¾"	1'-0"	3"	0'-9"	3-9-15 8.00	3-13-075 2.00	3-13-075 1.33		⅜	0.26	1.44
8'	4'-0"	1'-1"	0'-9½"	0'-6"	1'-7¼"	1'-0"	3"	0'-9"	3-9-20 8.00	3-13-10 2.00	3-13-10 2.00		⅜	0.32	1.61
9'	4'-6"	1'-2"	0'-11"	0'-6"	1'-9½"	1'-0"	3"	0'-9"	3-9-20 10.00	3-13-10 2.33	3-13-10 2.00		⅜	0.41	1.86
10'	5'-0"	1'-4"	1'-0"	0'-6"	2'-0"	1'-0"	3"	0'-9"	3-9-25 10.00	3-13-125 2.66	3-13-125 2.33		⅜	0.48	2.03
11'	5'-6"	1'-6"	1'-1"	0'-6½"	2'-2½"	1'-0"	3"	0'-9½"	3-9-30 12.00	3-9-15 2.66	3-9-15 2.66		½	0.57	3.89
12'	6'-0"	1'-7"	1'-2½"	0'-7"	2'-4¾"	1'-6"	4½"	0'-11½"	3-9-35 12.00	3-9-20 3.00	3-9-25 3.00		½	0.67	4.36
13'	6'-6"	1'-9"	1'-3½"	0'-8"	2'-7¼"	1'-6"	4½"	1'-0½"	3-6-45 8.00	3-9-20 3.33	3-9-25 3.00	3-9-20 6.00	½	0.80	4.67
14'	7'-0"	1'-11"	1'-5"	0'-8½"	2'-9½"	1'-6"	4½"	1'-1"	3-6-50 8.00	3-9-25 3.33	3-9-35 3.33	3-9-20 8.00	½	0.95	5.11
15'	7'-6"	2'-0"	1'-6"	0'-9"	3'-0"	1'-6"	4½"	1'-1½"	3-6-55 8.00	3-9-30 3.66	3-9-35 3.66	3-9-20 8.00	⅝	1.07	8.46
16'	8'-0"	2'-2"	1'-7"	0'-9½"	3'-2½"	2'-0"	6"	1'-3½"	2(3-9-35) 16.00	3-9-35 4.00	3-6-40 4.00	3-9-25 10.00	⅝	1.20	8.93
17'	8'-6"	2'-3"	1'-8½"	0'-10"	3'-4¾"	2'-0"	6"	1'-4"	2(3-9-35) 16.00	3-9-35 4.00	3-6-45 4.00	3-9-25 10.00	⅝	1.38	9.64
18'	9'-0"	2'-5"	1'-9½"	0'-11"	3'-7¼"	2'-0"	6"	1'-5"	2(3-6-40) 16.00	3-6-40 4.33	3-6-50 4.33	3-9-30 12.00	⅝	1.55	10.10
19'	9'-6"	2'-7"	1'-11"	0'-11½"	3'-9½"	2'-0"	6"	1'-5½"	2(3-6-45) 16.00	3-6-40 4.66	3-6-55 4.66	3-9-35 12.00	¾	1.74	15.57
20'	10'-0"	2'-8"	2'-0"	1'-0"	4'-0"	2'-0"	6"	1'-6"	2(3-6-50) 24.00	3-6-45 5.00	3-6-60 5.00	3-9-35 10.00	¾	1.91	16.24

RETAINING WALL

CANTILEVER TYPE

SLOPING FILL



SECTION

QUANTITIES PER LINEAR FOOT OF WALL
GIVEN IN TABLE

PLATE NO. II

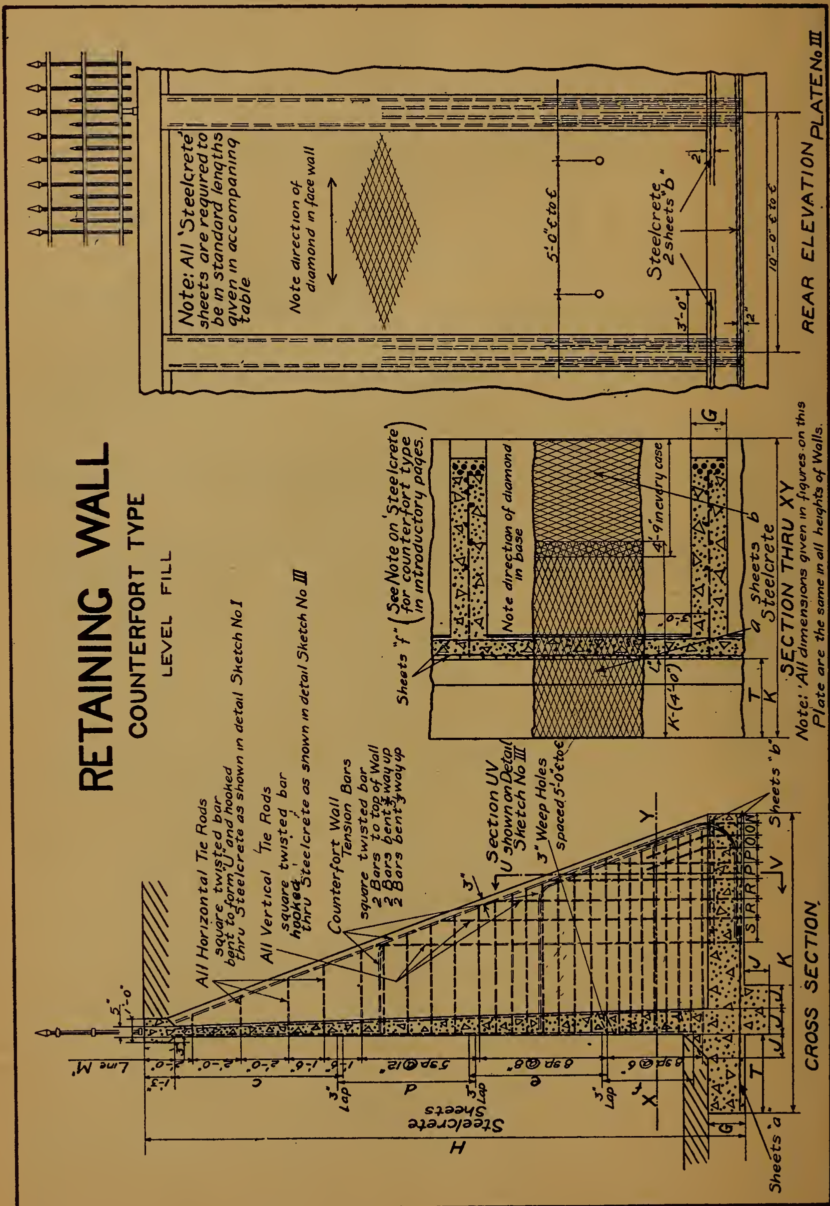
RETAINING WALL

CANTILEVER TYPE

SLOPING FILL

Table in connection with PLATE No. II

DIMENSIONS										STEELCRETE: Size of mesh and Sq. Ft. required per lin. ft of Wall (sheets)					Size of Bars	QUANTITIES per Lin. Ft of Wall	
Height	Base																
H	B	T	a	b	c	d	e	f	g	M	N	O	P	R	1 Ft. ¢ to ¢	Concrete Cu. Yds.	Bars Lbs.
6'	5'-6"	1'-7"	0'-9"	0'-9"	1'-10"	1'-0"	3"	1'-0"	2'-11"	3-9-35 6.00	3-9-20 2.33	3-9-30 3.00			1/2"	0.34	2.71
7'	6'-0"	1'-8"	0'-10½"	0'-9"	2'-0"	1'-0"	3"	1'-0"	3'-1½"	3-9-35 8.00	3-9-20 2.66	3-9-30 3.33			9/16	0.43	4.00
8'	6'-6"	1'-9"	1'-0"	0'-9"	2'-2"	1'-0"	3"	1'-0"	3'-4"	3-6-50 8.00	3-9-20 2.66	3-9-35 4.00			5/8	0.52	5.55
9'	7'-0"	1'-10"	1'-1½"	0'-9"	2'-4"	1'-0"	3"	1'-0"	3'-6½"	3-6-40 12.00	3-9-20 3.00	3-9-35 4.00	3-6-40 8.00		11/16	0.62	7.69
10'	7'-6"	1'-11"	1'-3"	0'-9"	2'-6"	1'-0"	3"	1'-0"	3'-9"	2(3-6-40) 16.00	3-9-20 3.33	3-6-45 4.00	3-9-30 10.00		3/4	0.74	10.17
11'	8'-0"	2'-0"	1'-4½"	0'-9"	2'-8"	1'-0"	3"	1'-0"	3'-11½"	3-6-40 12.00	3-9-25 3.33	3-6-50 4.33	3-6-60 8.00		13/16	0.87	13.13
12'	8'-6"	2'-1"	1'-6"	0'-9"	2'-10"	1'-0"	3"	1'-0"	4'-2"	3-6-60 8.00	3-9-25 3.33	3-6-55 4.66	3-6-60 12.00		7/8	1.01	16.59
13'	9'-0"	2'-3"	1'-7½"	0'-10"	3'-0"	1'-6"	4½"	1'-2½"	4'-4½"	3-6-60 12.00	3-9-25 3.66	3-6-60 5.00	3-6-60 8.00	3-9-35 6.00	15/16	1.17	20.65
14'	9'-8"	2'-4"	1'-9"	0'-10"	3'-3"	1'-6"	4½"	1'-2½"	4'-8"	2(3-6-55) 24.00	3-9-30 4.00	3-6-60 5.33	3-6-55 8.00	3-9-15 4.00	15/16	1.33	22.25
15'	10'-4"	2'-5"	1'-10½"	0'-10"	3'-5"	1'-6"	4½"	1'-2½"	5'-0½"	3-6-60 12.00	3-9-35 4.00	2(3-6-40) 12.00	2(3-6-60) 16.00	3-9-15 4.00	1	1.51	27.10
16'	11'-0"	2'-6"	2'-0"	1'-0"	3'-8"	1'-6"	4½"	1'-2½"	5'-4"	2(3-6-60) 24.00	3-9-35 4.66	2(3-6-45) 12.00	3-6-60 8.00	3-9-25 6.00	1	1.78	28.90
17'	11'-8"	2'-8"	2'-1½"	1'-0"	3'-10"	2'-0"	6"	1'-6"	5'-8½"	2(3-6-60) 24.00	3-9-35 5.00	2(3-6-50) 12.00	3-6-60 8.00	3-9-35 6.00	1	1.96	30.70
18'	12'-4"	2'-10"	2'-3"	1'-0"	4'-1"	2'-0"	6"	1'-6"	6'-0"	2(3-6-60) 24.00	3-6-45 5.00	2(3-6-60) 16.00	3-6-60 8.00	3-9-35 8.00	1 1/8	2.17	41.65
19'	13'-0"	3'-0"	2'-4½"	1'-0"	4'-4"	2'-0"	6"	1'-6"	6'-3½"	2(3-6-60) 24.00	3-6-50 5.33	2(3-6-60) 16.00	3-6-60 8.00	3-6-50 8.00	1 1/8	2.29	43.50
20'	14'-0"	3'-3"	2'-6"	1'-0"	4'-8"	2'-0"	6"	1'-6"	6'-10"	3-6-60 8.00	3-6-55 6.00	2(3-6-60) 16.00	2(3-6-60) 24.00	3-6-60 8.00	1 1/8	2.66	45.75


RETAINING WALL
COUNTERFORT TYPE
LEVEL FILL
Note: All 'Steelcrete' sheets are required to be in standard lengths given in accompaning table
Note direction of diamond in face wall
5'-0" ℄ to ℄
Steelcrete 2 Sheets "b"
3'-0"
10'-0" ℄ to ℄
REAR ELEVATION
PLATE No III
Sheets "f" (See Note on 'Steelcrete' for counterfort type in introductory pages.)
Note direction of diamond in base
4'-9" in every case
Sheets b
Steelcrete
a
SECTION THRU XY
Note: 'All dimensions given in figures on this Plate are the same in all heights of Walls.
All Horizontal Tie Rods square twisted bar bent to form 'U' and hooked thru Steelcrete as shown in detail Sketch No I
All Vertical Tie Rods square twisted bar hooked thru Steelcrete as shown in detail Sketch No III
Counterfort Wall Tension Bars square twisted bar 2 Bars to top of Wall 2 Bars bent ⅔ way up 2 Bars bent ⅓ way up
Section UV shown on Detail Sketch No III
3" Weep Holes Spaced 5'-0" ℄ to ℄
Line M.
Steelcrete Sheets
Lap
Sheets "a"
Sheets "b"
CROSS SECTION

RETAINING WALL

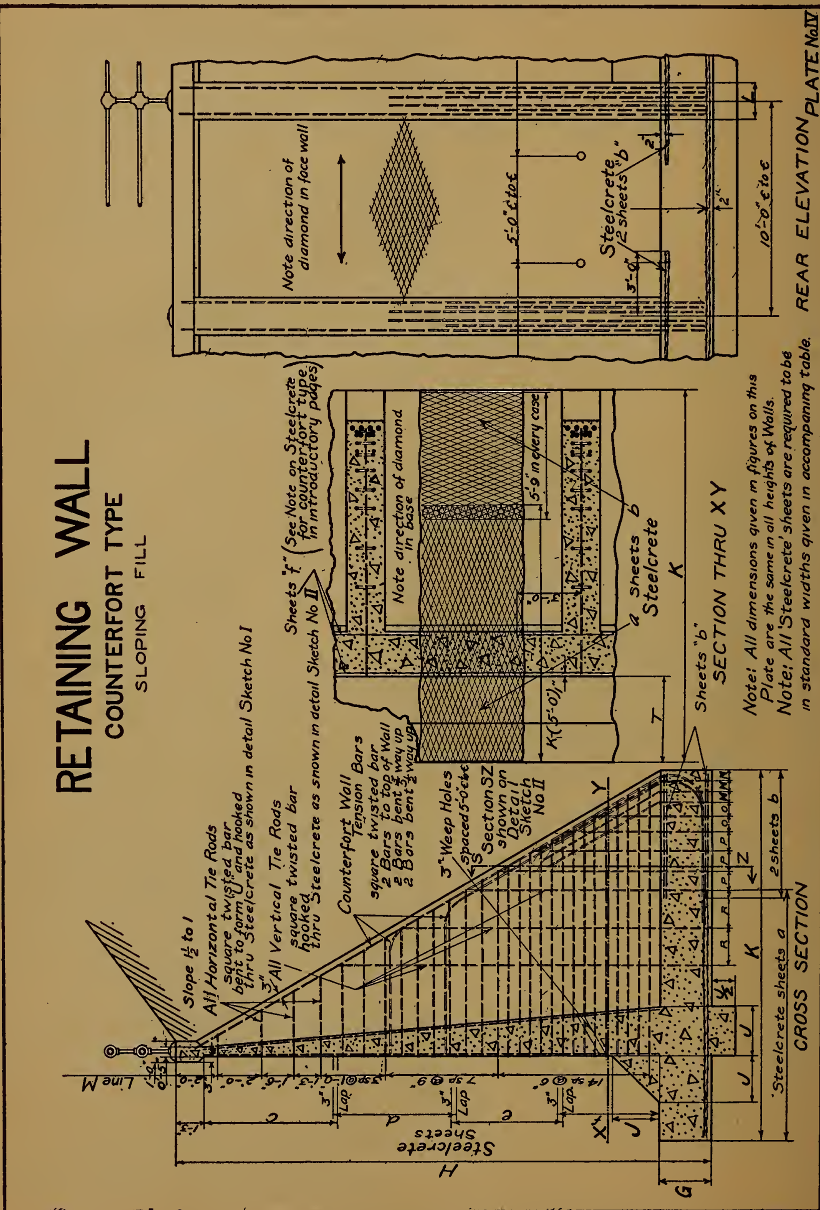
COUNTERFORT TYPE

LEVEL FILL

SPACING OF VERTICAL TIE RODS															
	Spacing in inches														
	Height														
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
O	3	3	3	3	4	4	4	4	4	6	6	6	6	6	6
P	4	4	4	4	6	6	6	6	6	8	8	8	8	8	8
R	5	5	5	5	7	7	7	7	7	10	10	10	10	10	10
S	6	6	6	6	9	9	9	9	9	12	12	12	12	12	12

Tables in connection with PLATE No. III

DIMENSIONS					STEELCRETE Size of mesh and Quantities required per 10'-0" Section										BARS Weight per 10'-0" Section Cold Twisted Square Steel						Concrete per 10'-0" Section Cubic Yards
	HEIGHT				SHEETS AS DESIGNATED ON PLATE III										Vertical Ties		Horizontal Ties		Tension Bars		
H	K	T	G	J	a	b	c	d	Sq. Ft.	e	Sq. Ft.	f	Sq. Ft.	Size	Wt. in lbs.	Size	Wt. in lbs.	Size	Wt. in lbs.	
11'	5'-6"	1'-6"	1'-0"	0'-7"	3-9-20 15.8 Sq. Ft.	158 SQ. FT.	167 SQ. FT.	3-6-50	33.3					1/2"	33	1/2"	18	1/2"	58	5.4
12'	6'-0"	1'-7"	1'-0"	0'-7"	3-9-25 21.0 Sq. Ft.				50.0					1/2	33	"	22	1/2	62	5.8
13'	6'-6"	1'-9"	1'-0"	0'-7"	3-9-30 26.3 Sq. Ft.				66.7					1/2	33	"	28	5/8	104	6.4
14'	7'-0"	1'-11"	1'-0"	0'-10"	3-9-35 31.5 Sq. Ft.				83.3					1/2	33	"	33	5/8	110	7.6
15'	7'-6"	2'-0"	1'-2"	0'-10"	3-9-35 36.8 Sq. Ft.				96.0					1/2	43	"	34	11/16	137	8.8
16'	8'-0"	2'-2"	1'-2"	0'-10"	3-6-45 42.0 Sq. Ft.				96.0	3-6-55	22.2			9/16	55	"	44	11/16	145	9.5
17'	8'-6"	2'-3"	1'-2"	0'-11"	3-6-55 47.3 Sq. Ft.				96.0		38.8			9/16	55	"	51	3/4	182.	10.6
18'	9'-0"	2'-5"	1'-2"	0'-11"	3-6-60 52.5 Sq. Ft.	3-6-60	3-6-40		96.0		55.5			5/8	68	"	63	3/4	192	11.2
19'	9'-6"	2'-7"	1'-4"	0'-11"	3-6-60 57.8 Sq. Ft.				96.0		69.5			5/8	68	"	70	3/4	203	12.7
20'	10'-0"	2'-8"	1'-4"	1'-0"	2(3-6-40) 126.0 Sq. Ft.				96.0		86.3			5/8	89	"	83	13/16	249	14.0
21'	10'-6"	2'-10"	1'-4"	1'-0"	2(3-6-40) 136.5 Sq. Ft.				96.0		87.5			5/8	89	"	89	7/8	302	14.8
22'	11'-0"	2'-11"	1'-4"	1'-0"	2(3-6-40) 147.0 Sq. Ft.				96.0		87.5	3-6-60	27.8	11/16	108	"	103	15/16	362	15.7
23'	11'-6"	3'-1"	1'-6"	1'-0"	2(3-6-40) 157.5 Sq. Ft.				96.0		87.5		41.7	11/16	108	"	117	1	425	17.9
24'	12'-0"	3'-2"	1'-6"	1'-0"	2(3-6-45) 168.0 Sq. Ft.				96.0		87.5		58.4	3/4	128	"	131	1	442	18.9
25'	12'-6"	3'-4"	1'-6"	1'-0"	2(3-6-50) 178.5 Sq. Ft.				96.0		87.5		79.3	3/4	128	"	137	1	460	19.9


RETAINING WALL
COUNTERFORT TYPE
SLOPING FILL
PLATE No IV
Note direction of diamond in face wall
5'-0" ℄ to ℄
Steelcrete "b" (2 sheets)
10'-0" ℄ to ℄
REAR ELEVATION
Sheets "f" (See Note on Steelcrete for counterfort type in introductory pages)
Note direction of diamond in base
5'-9" in every case
a Sheets b Steelcrete
Sheets "b"
SECTION THRU XY
Note: All dimensions given in figures on this Plate are the same in all heights of Walls.
Note: All 'Steelcrete' sheets are required to be in standard widths given in accompanying table.
Slope 1½ to 1
All Horizontal Tie Rods square twisted bar bent to form "U" and hooked thru Steelcrete as shown in detail Sketch No I
All Vertical Tie Rods square twisted bar hooked thru Steelcrete as shown in detail Sketch No II
Counterfort Wall Tension Bars square twisted bar 2 Bars to top of Wall 2 Bars bent ⅔ way up 2 Bars bent ⅓ way up
3" Weep Holes Spaced 5'-0" ℄ to ℄
Section SZ shown on Detail Sketch No II
2 sheets b
'Steelcrete sheets a
CROSS SECTION
Steelcrete Sheets
Line M

RETAINING WALL

COUNTERFORT TYPE

SLOPING FILL

STANDARD SIZES OF SQUARE BAR

Size	Area	Wt./lin.Ft.
1/2	.2500□"	.850#
9/16	.3164	1.076
5/8	.3906	1.328
11/16	.4727	1.607
3/4	.5625	1.913
13/16	.6602	2.245
7/8	.7656	2.603
15/16	.8789	2.988
1	1.0000	3.400
1 1/8	1.2656	4.303
1 1/4	1.5625	5.312
1 3/8	1.8906	6.428
1 1/2	2.2500	7.650

SPACING OF VERTICAL TIE RODS

Spacing in inches

Height	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
N	3	3	3	3	3	4	4	4	4	4	6	6	6	6	6
O	5	5	5	5	5	6	6	6	6	6	8	8	8	8	8
P	6	6	6	6	6	8	8	8	8	8	11	11	11	11	11
R	11	11	11	11	11	15	15	15	15	15	21	21	21	21	21

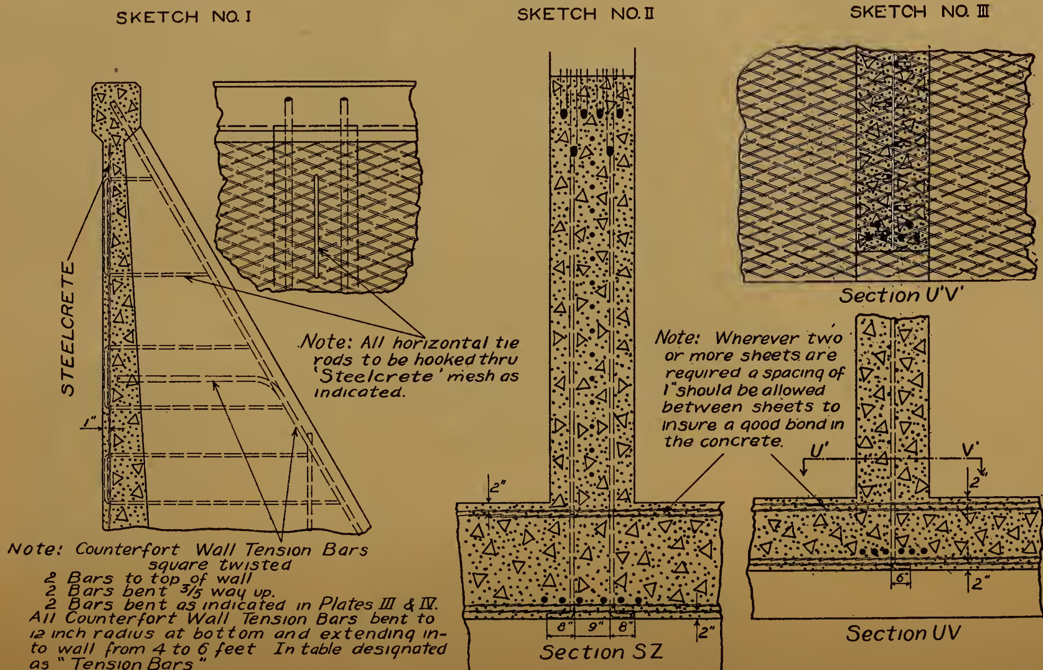
STANDARD SIZES STEELCRETE

Size	Area/Ft.W.	Wt./Sq.Ft.	Width	Length
3-13-075	.075 sq.in.	.27 lbs.	6'-0"	Standard Lengths 8'-0" and 12'-0"
3-13-10	.10 "	.37 "	6'-9"	
3-13-125	.125 "	.46 "	5'-3"	
3-13-15	.15 "	.55 "	7'-0"	
3-9-20	.20 "	.73 "	5'-3"	
3-9-25	.25 "	.92 "	4'-0"	
3-9-30	.30 "	1.10 "	7'-0"	
3-9-35	.35 "	1.28 "	6'-0"	
3-6-40	.40 "	1.46 "	7'-0"	
3-6-45	.45 "	1.65 "	6'-3"	
3-6-50	.50 "	1.83 "	5'-9"	
3-6-55	.55 "	2.01 "	5'-3"	
3-6-60	.60 "	2.19 "	4'-9"	

Tables in connection with PLATE No. IV

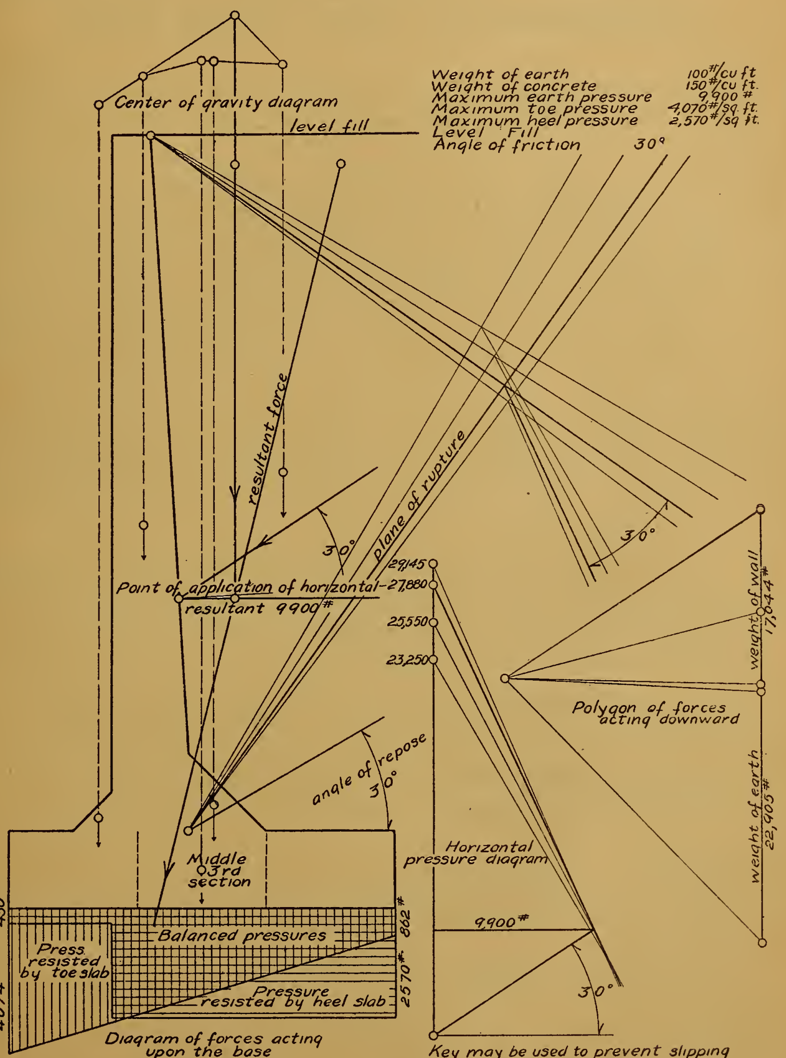
DIMENSIONS	HEIGHT					STEELCRETE Size of mesh and Quantities required per 10'-0" Section. SHEETS AS DESIGNATED ON PLATE IV									BARS Weight per 10'-0" Section Cold Twisted Square Steel						Concrete per 10'-0" Section Cubic Yards
H	K	T	G	J	L	a	b	c	d	Sq.Ft.	e	Sq.Ft.	f	Sq.Ft.	Vertical Ties Size	Vertical Ties Wt. in lbs.	Horizontal Ties Size	Horizontal Ties Wt. in lbs.	Tension Bars Size	Tension Bars Wt. in lbs.	
11'	8'-0"	2'-0"	1'-3"	1'-1"	1'-3"	3-9-25 31.50 Sq.Ft.	1917 SQ.FT. 3-6-50	1042 SQ.FT. 3-6-45	3-6-50	41.65					1/2"	117	5/8"	31	11/16"	142	8.2
12'	8'-6"	2'-1"	1'-4"	1'-2"	1'-4"	3-9-30 36.75 Sq.Ft.				56.80					1/2	117	"	47	3/4	180	9.4
13'	9'-0"	2'-3"	1'-5"	1'-3"	1'-5"	3-9-30 42.00 Sq.Ft.				71.60					1/2	117	"	56	13/16	229	11.1
14'	9'-8"	2'-4"	1'-6"	1'-4"	1'-6"	3-9-35 49.00 Sq.Ft.				87.50					1/2	117	"	65	7/8	287	12.3
15'	10'-4"	2'-5"	1'-7"	1'-5"	1'-7"	3-6-40 56.00 Sq.Ft.				96.00	3-6-55	11.10			1/2	117	"	76	15/16	350	14.0
16'	11'-0"	2'-6"	1'-8"	1'-6"	1'-8"	3-6-45 63.00 Sq.Ft.				96.00		26.35			9/16	180	"	87	15/16	374	15.9
17'	11'-8"	2'-8"	1'-9"	1'-7"	1'-9"	3-6-45 70.00 Sq.Ft.				96.00		41.70			9/16	180	"	110	1	449	18.2
18'	12'-4"	2'-10"	1'-10"	1'-8"	1'-9"	3-6-55 77.00 Sq.Ft.				96.00		57.00			5/8	222	"	134	1 1/8	603	19.7
19'	13'-0"	3'-0"	1'-11"	1'-9"	1'-9"	3-6-60 84.00 Sq.Ft.				96.00		72.22			5/8	222	"	160	1 1/8	637	21.8
20'	13'-8"	3'-2"	2'-0"	1'-10"	1'-9"	2(3-6-40) 182.00 Sq.Ft.				96.00		87.50			5/8	222	"	173	1 1/4	823	23.9
21'	14'-4"	3'-4"	2'-1"	1'-11"	1'-9"	2(3-6-40) 196.00 Sq.Ft.				96.00		87.50	3-6-60	19.50	5/8	284	"	202	1 1/4	866	26.0
22'	15'-0"	3'-6"	2'-2"	2'-0"	1'-9"	2(3-6-40) 210.00 Sq.Ft.				96.00		87.50		34.70	11/16	344	"	231	1 3/8	1093	28.4
23'	15'-8"	3'-8"	2'-3"	2'-1"	1'-9"	2(3-6-45) 224.50 Sq.Ft.				96.00		87.50		50.00	11/16	344	"	263	1 3/8	1150	30.8
24'	16'-6"	3'-10"	2'-4"	2'-2"	1'-9"	2(3-6-50) 241.50 Sq.Ft.				96.00		87.50		65.40	3/4	410	"	296	1 1/2	1424	33.5
25'	17'-4"	4'-0"	2'-5"	2'-3"	1'-9"	2(3-6-55) 259.00 Sq.Ft.				96.00		87.50		80.70	3/4	410	"	315	1 1/2	1485	36.8

RETAINING WALL
COUNTERFORT TYPE
DETAILS



RETAINING WALL

GRAPHICAL SOLUTION



"Steelcrete" Mesh and the Building Ordinance of New York City

THE following résumé of the new Building Ordinance of New York City is of interest to all students and searchers of reinforced concrete data:

Heretofore, in order to use any type of reinforcement in cinder concrete construction in New York City, it was necessary to have a load test of the system made, subject to the approval of the Building Department. Under the general ordinance covering fireproof construction, recently adopted by the City of New York the above method of procedure has been abolished, and a new method of computation has been devised, whereby the allowable capacities of floor slabs may be determined without resorting to tests.

However, this new method of computation is limited in its application, covering only flat slabs of either stone or cinder concrete between steel beams spaced not more than eight feet apart, the minimum thickness of slab allowed being four inches.

Besides specifying the minimum thickness of slab, and the maximum span between steel beams, the new ordinance also regulates the requirements as to conditions of continuity, the amount and kind of reinforcement to be used, weights of materials and superimposed loads.

Following are the clauses copied from the new ordinance which govern this type of construction:

The weights of various materials in pounds per cubic foot shall be assumed to be as follows:

Brickwork	120
Concrete, cinder, used for floor arches or slabs	108
Concrete, cinder, used for filling over fireproof floors	60
Concrete, stone	144
Granite, bluestone and marble	168
Limestone	156
Sandstone	144

Loads

The term "dead load" means the weight of walls, partitions, framing, floors, roofs and all permanent construction entering into any building.

The term "live load" means all forms of loading other than the weight of the material entering into the construction of the building.

Every floor, roof, yard, court or sidewalk shall be of sufficient strength in all parts to bear safely any imposed loads, whether permanent or temporary, in addition to the dead loads depending thereon, provided, however, that no floor in any building or extension to an existing building hereafter erected, shall be designed to carry less than the following live loads per square foot of area, uniformly distributed, according as the floor may be intended or used for the purposes indicated:

40 pounds for residence purposes;

100 pounds for places of assembly or public purpose, except that for classrooms of schools or other places of instruction the floor need not be designed for more than 75 pounds, and

120 pounds for any other purpose except that the floors of offices need not be designed for more than 60 pounds.

The live loads for which any and every floor may be designed shall be clearly shown in the application and on the plans before any permit to erect is issued.

Every roof hereafter erected, shall be proportioned to bear safely a live load of 40 pounds per square foot of surface when the pitch of such roof is twenty degrees or less with the horizontal and thirty pounds per square foot measured on a horizontal plane, when the pitch is more than twenty degrees.

For sidewalks between the curb and building lines, the live load shall be taken at 300 pounds per square foot.

Concrete Floor Arches

When concrete is used as floor filling it shall consist of one part of Portland cement, and not more than two parts of sand and five

parts of stone, gravel or cinders, reinforced in the case of slab constructions with steel as herein provided. The stone or gravel shall be as required elsewhere in this chapter for reinforced concrete. Cinders shall be clean, well burned steamboiler cinders.

When reinforcement is required it shall consist of steel rods or other suitable shapes, or steel fabric. The tensional reinforcement in any case shall be not less than twelve-hundredths per cent, in the case of cold drawn steel fabric, nor less than twenty-five hundredths per cent in the case of other forms, the percentage being based on the sectional area of slab above the center of the reinforcement. The center of the reinforcement shall be at least one inch above the bottom of the slab, but in no case shall any part of the reinforcement come within five-eighths of an inch from the bottom of the slab.

When the concrete floor filling is used in the form of segmental arches, the thickness shall be at least four inches at the crown. Such arches shall have a rise of not less than one inch for each foot of span.

When the concrete floor filling is in the form of slabs the thickness shall be not less than four inches, except as otherwise provided in this article for special roof construction.

In determining the safe carrying capacity of concrete slab floor fillings the gross load in pounds per square foot of floor surface shall not exceed the product of the depth in inches of the reinforcement below the top of the slab, by the cross sectional area in square inches per foot of width of the tensional steel, divided by the square of the span in feet, all multiplied by the following co-efficients when cinder concrete is used, 14,000 if the reinforcement is not continuous over the supports, 18,000 if the reinforcement consists of rods or other shapes securely hooked over or attached to the supports, and 26,000 if the reinforcement consists of steel fabric continuous over the supports, and when stone concrete is used, 16,000, 20,000 and 30,000 respectively.

In fireproof buildings the span of any floor filling shall not exceed eight feet except when reinforced concrete or reinforced terra cotta is used.

The following tables have been prepared based on the above requirements and give the loads which various weights of "Steelcrete" Mesh carry on spans from four to eight feet when used as reinforcement for a four-inch slab of cinder concrete. Table No. 1 is computed on the basis of the "Steelcrete" Mesh being continuous over the supports, and applies to the usual type of reinforced concrete slab.

Table No. 1 — (Reinforcement Continuous)

Steelcrete Mesh Required	Spans	Gross Load Pounds per sq. ft.	Applied Load Pounds per sq. ft.
3-13-075 Sectional Area per foot of width .075 sq. inches Wt. .27 lbs. per sq. ft.	4′ 0″	366	330
	4′ 6″	289	253
	5′ 0″	234	198
	5′ 6″	194	158
	6′ 0″	163	127
	6′ 6″	139	103
	7′ 0″	120	84
	7′ 6″	104	68
	8′ 0″	92	56
3-13-10 Sectional Area per foot of width .10 sq. inches Wt. .37 lbs. per sq. ft.	4′ 6″	385	349
	5′ 0″	312	276
	5′ 6″	258	222
	6′ 0″	217	181
	6′ 6″	185	149
	7′ 0″	159	123
	7′ 6″	139	103
	8′ 0″	122	86
3-13-125 Sectional Area per foot of width .125 sq. inches Wt. .46 lbs. per sq. ft.	5′ 0″	390	354
	5′ 6″	323	287
	6′ 0″	271	235
	6′ 6″	231	195
	7′ 0″	199	163
	7′ 6″	173	137
	8′ 0″	152	116
3-9-15 Sectional Area per foot of width .15 sq. inches Wt. .55 lbs. per sq. ft.	5′ 6″	387	351
	6′ 0″	325	289
	6′ 6″	277	241
	7′ 0″	239	203
	7′ 6″	208	172
	8′ 0″	183	147

Table No. 2 — (Reinforcement Non-Continuous)

Steelcrete Mesh Required	Spans	Gross Load Pounds per sq. ft.	Applied Load Pounds per sq. ft.
3-13-075 Sectional Area per foot of width .075 sq. inches Wt. .27 lbs. per sq. ft.	4′ 0″	197	161
	4′ 6″	156	120
	5′ 0″	126	90
	5′ 6″	104	68
	6′ 0″	88	52
	6′ 6″	75	39
3-13-10 Sectional Area per foot of width .10 sq. inches Wt. .37 lbs. per sq. ft.	4′ 0″	263	227
	4′ 6″	207	171
	5′ 0″	168	132
	5′ 6″	139	103
	6′ 0″	117	81
	6′ 6″	100	64
	7′ 0″	86	50
	7′ 6″	75	39
3-13-125 Sectional Area per foot of width .125 sq. inches Wt. .46 lbs. per sq. ft.	4′ 0″	328	292
	4′ 6″	259	223
	5′ 0″	210	174
	5′ 6″	174	138
	6′ 0″	146	110
	6′ 6″	124	88
	7′ 0″	107	71
	7′ 6″	93	57
	8′ 0″	82	46
3-9-15 Sectional Area per foot of width .15 sq. inches Wt. .55 lbs. per sq. ft.	4′ 0″	394	358
	4′ 6″	311	275
	5′ 0″	252	216
	5′ 6″	208	172
	6′ 0″	175	139
	6′ 6″	149	113
	7′ 0″	129	93
	7′ 6″	112	76
	8′ 0″	99	63

Tests of "Steelcrete" Mesh

"STEELCRETE" Expanded Metal has been tested innumerable times in the course of its extensive use. The following tests made by Prof. Frank M. McCullough of the Carnegie Institute of Technology are hereby given because of the extreme and unusual scientific pains taken to obtain the results.

Tests on cinder concrete floor arches or slabs made in the Materials Testing Laboratory of the Carnegie Technical Schools during the spring of 1911. The purpose of the tests was to determine the efficiency of expanded metal in flat arch or slab construction.

Tests were made on four arches and three sizes of expanded metal. The slabs were loaded with pig iron and deflection readings were taken at increments of about 150 lbs. per sq. ft. in the loading. The age of the slabs when tested varied from 54 to 61 days.

Material

Lehigh cement, local sand dredged from the river, and screened anthracite cinders were used. The cement passed the American Society for Testing Materials specifications. The weight per cu. ft. of the damp cinders and sand was 48 lbs. and 82 lbs., respectively; the voids of the dry cinders and sand were equal to 59 per cent and 44 per cent, respectively.

After making a series of volumetric tests of the materials it was decided to use a 1:2½:4½ concrete instead of a 1:2:5, the proportions being based on dry sand and cinders. The concrete was thoroughly mixed by machine and was of a wet consistency. During the pouring of the slabs samples of the concrete were taken which, when tested in the form of cylinders, 6 inches in diameter and 18 inches high, gave crushing strengths of 631 and 785 lbs. per square inch at 33 days and 56 days, respectively.

Method of Construction

A foundation of 1:2:4 gravel concrete, 12 in. thick and about 3 ft. high, was first built. Upon this foundation were embedded bearing plates which supported the I-beams of the flat arches or slabs.

Each of the arches was of the flat type and was carried by two 12 in. 31½ lb. I-beams spaced 6 ft. on centers. These I-beams were connected by two ¾-in. steel rods with nuts set so that there was little initial tension in the rods. The length of the arches was 6 ft., the thickness at the center and haunches was 4 in. and 15 in., respectively.

The arches were all reinforced with sheets of "Steelcrete" Expanded Metal; arches O and Q with 3-13-075, N with 3-9-175, and P with 3-9-15.

The cross-sections of the sheets of metal used in the arches checked these values within commercial limits.

The details of the arches and the position of the reinforcement are shown in Fig. 12.

Method of Testing

The pig iron was piled in three separate tiers, each parallel to the I-beams in order to reduce the arching effect to a minimum. Deflections were obtained at seven points, these points being located at the center of the slab and at the center and ends of each I-beam carrying the slab.

At these points holes were left in the concrete in which were embedded slender wooden rods carrying scales at the top. By means of a Y level these scales were read to $\frac{1}{64}$ of an inch for increments of 150 lbs. per sq. ft. in the loading, this unit load being based on the total area of the slab which was 36 sq. ft. In order to detect any change in the height of instrument, level readings were frequently taken on a permanent bench mark entirely separate from the slabs.

Results of Tests

The detailed results are tabulated in Tables 1 to 4, inclusive. Deflections are given in 64ths of an inch; negative values indicate a downward movement and positive values an upward movement of the slab. Rods No. 1, No. 3, No. 5 and No. 7 were located at the ends of the 12-in. I-beams carrying the slabs, rods No. 2 and No. 6 at the centers of these I-beams, and

rod No. 4 at the center of the slab (See Fig. 12). The missing deflections are due to the fact that it was impossible to read all of the rods after the pig iron had reached a height of about 6 ft.

Discussion of Results

The arches were built in order to study their behavior under a total load of 54,000 lbs. or a unit load of 1,500 lbs. per sq. ft. and all of the arches were in excellent condition under this test load. At this load the deflection of the center of the slab below the center of the I-beams varied from $\frac{13}{64}$-in. for slab N to $\frac{20}{64}$-in. for slabs Q and P. When this maximum load was allowed to remain for five days on slab O, which had the lightest reinforcement, the increase in deflection was only $\frac{1}{64}$-in. When the slabs were fully loaded, tension cracks were seen in the concrete near the center lines and above the I-beams at the haunches, these latter cracks being much smaller, but in none of the arches were any of the cracks serious.

After the full load of 1,500 lbs. per sq. ft. had been placed on slab P it was decided to continue the loading to failure. Under a load of 2,230 lbs. per sq. ft. the slab failed but this was apparently caused by the falling and consequent impact effect of the piles of pig iron which were about 12 ft. high and quite unstable. The rate of increase in the deflection readings did not indicate approaching failure nor did the fracture show an initial failure of the slab.

The maximum load carried by the slab indicated that considerable arch action was developed and that the slabs should not be considered as fixed beams, for, assuming the slab to be a fixed beam, the maximum computed stress in the steel for a load of 1,500 lbs. per sq. ft. was about three times as great as the ultimate strength of the steel as determined in a tension test. It was also observed that the ¾-in. rods connecting the 12-in. I-beams which had little initial tension, were under a heavy tensile stress when the slab carried its full load.

The tension cracks in the concrete at the haunches were very fine and did not increase in width as did the cracks at the center of the arch, thus indicating little tension in the arch above the haunches.

Table I

Slab Q. Age — 54 days. Reinforcement 3-13-075.

Deflections in 64ths of an inch

Unit Load in Lbs. per sq. ft.	Rod No. 1	Rod No. 2	Rod No. 3	Rod No. 4	Rod No. 5	Rod No. 6	Rod No. 7
0	0	0	0	0	0	0	0
154	—1	0	—1	— 1	0	0	0
303	—1	—1	0	— 2	+1	0	—1
457	—1	—1	—1	— 3	0	—1	—1
609	—1	—1	—1	— 4	0	—1	—1
760	—1	—2	—1	— 6	—1	—1	—1
911	—1	—2	—1	— 8	—1	—2	—1
1069	—1	—3	—1	—11	—1	—2	—1
1219	—1	—3	—1	—15	—1	—3	—1
1368	—1	...	...	—20	—1	—3	—1
1501	—1	...	...	—24	—1	—4	—1

Note — The maximum deflection of No. 4 referred to No. 6 was $\frac{20}{64}$ in. The maximum load was allowed to remain on the slab for 15 hours and no increase in deflection was noted.

Table II

Slab P. Age — 55 days. Reinforcement 3-9-15.

Deflections in 64ths of an inch

Unit Load in Lbs. per sq. ft.	Rod No. 1	Rod No. 2	Rod No. 3	Rod No. 4	Rod No. 5	Rod No. 6	Rod No. 7
0	0	0	0	0	0	0	0
181	—1	—1	—1	— 4	—1	—1	—1
360	—1	—2	—1	— 6	—1	—1	—1
539	—1	—2	—1	— 8	—1	—1	—1
706	—1	—3	—1	—12	—1	—2	—1
861	—2	—3	—1	—13	—1	—2	—2
1008	—2	—3	—1	—15	—1	—2	—2
1159	—2	—3	—1	—17	—1	—3	—2
1315	—2	—4	—1	—20	—1	—3	—2
1467	—3	...	...	—24	—1	—4	—2
1619	—3	...	...	—27	—1	—4	—2
1770	—3	...	...	—30	—1	—4	—2
1923	—3	...	...	—34	—1	—5	—2
2075	—2	...	...	—38	—1	—4	—2
2230	Failure Occurred						

Note — The maximum deflection of No. 4 referred to No. 6 was $\frac{34}{64}$ in.

Table III

Slab O. Age — 56 days. Reinforcement 3-13-075.

Unit Load in Lbs. per sq. ft.	Deflections in 64ths of an inch						
	Rod No. 1	Rod No. 2	Rod No. 3	Rod No. 4	Rod No. 5	Rod No. 6	Rod No. 7
0	0	0	0	0	0	0	0
166	0	—1	0	— 1	—1	0	—1
326	+1	0	+1	0	0	+1	+1
488	+1	0	+1	— 1	0	0	+1
635	+1	0	+1	— 2	0	0	+1
796	+1	0	+1	— 3	0	0	+1
948	+1	—1	+1	— 6	0	0	+1
1080	+1	—1	+1	— 8	0	—1	+1
1224	+1	—2	+1	—12	0	—1	+1
1355	+1	—2	+1	—15	...	...	+1
1501	+1	—2	+1	—19	...	...	+1

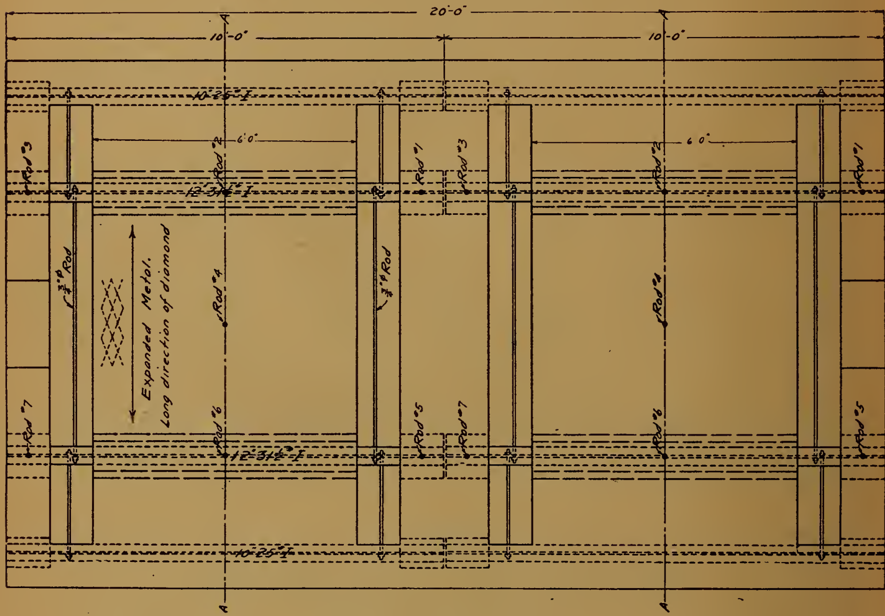
Note — The maximum deflection of No. 4 referred to No. 6 was $\frac{17}{64}$ of an inch. The maximum load was allowed to remain on the slab for 5 days and the increase in deflection at the center of the slab was $\frac{1}{64}$ of an inch. On removing the load a permanent set of ⅛ of an inch was observed at this point.

Table IV

Slab N. Age — 61 days. Reinforcement 3-9-175.

Unit Load in Lbs. per sq. ft.	Deflections in 64ths of an inch						
	Rod No. 1	Rod No. 2	Rod No. 3	Rod No. 4	Rod No. 5	Rod No. 6	Rod No. 7
0	0	0	0	0	0	0	0
174	0	—1	0	— 1	0	—1	—1
332	0	—1	—1	— 3	0	—1	—1
498	—1	—2	—1	— 4	—1	—2	—1
664	—1	—2	—1	— 5	—1	—3	—1
833	—1	—3	—1	— 7	—1	—4	—1
1024	—2	—4	—1	— 9	—1	—4	—2
1177	—2	—4	—1	—12	—1	—5	—2
1319	—2	—4	—1	—14	—1	...	—2
1395	—2	—5	—1	—16	—1	...	...
1555	—2	—5	—1	—18	—1	...	...
1702	—2	—5	—1	—19	—1	...	...

Note — The maximum deflection of No. 4 referred to No. 2 was $\frac{14}{64}$ of an inch. The maximum load was allowed to remain on the slab for 15 hours and the deflection at the center of the slab increased $\frac{1}{64}$ of an inch.


20'-0"
10'-0"
10'-0"
10"-25# I
12"-31½# I
6'-0"
Rod #1
Rod #2
Rod #3
Rod #4
Rod #5
Rod #6
Rod #7
¾"ϕ Rod
Expanded Metal.
Long direction of diamond
A
A

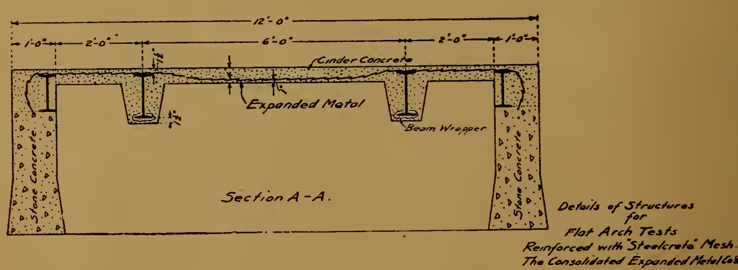
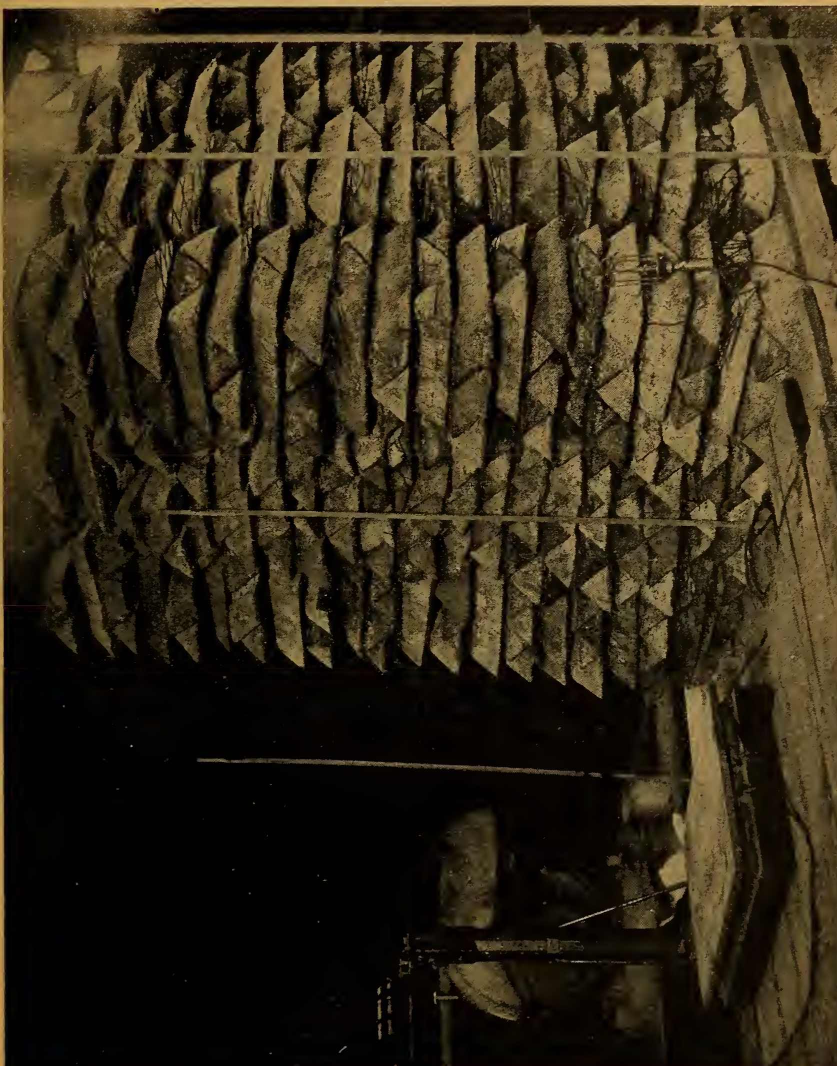

12'-0"
1'-0"
2'-0"
6'-0"
2'-0"
1'-0"
Cinder Concrete
Expanded Metal
Beam Wrapper
Stone Concrete
Section A-A.
Details of Structures for Flat Arch Tests
Reinforced with "Steelcrete" Mesh.
The Consolidated Expanded Metal Co's.

Fig. 12



Slab O, reinforced with 3-13-075. Load of 1500 lbs. per sq. ft. Deflection = $\frac{17}{64}$ of an inch

Columbia University Tests

THE following chapter offers a discussion of tensile tests conducted by Prof. James S. Macgregor of the Columbia University Testing Laboratory, establishing a stress-strain diagram obtained by extensometer readings.

Columbia University
in the City of New York
DEPARTMENT OF CIVIL ENGINEERING

The Consolidated Expanded Metal Co's., Braddock, Pennsylvania.

July 8, 1914

Gentlemen:—

Agreeable to your request I have made tension tests of your "Steelcrete" Mesh, the data for which I beg to enclose.

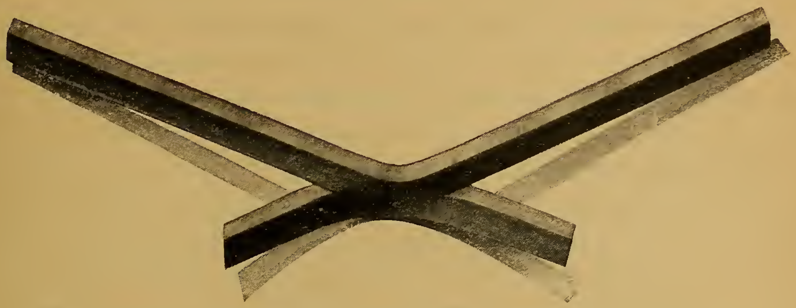
In preparing a test specimen, I cut a strand about seven inohes long from the center of a sheet of Mesh. The strand included at its central part short lengths of the adjoining diamond. A cross section at the bridge (or center connection) equal to that of the strand between the bridges was obtained by filing. After this operation the test specimen represented the side of a diamond, including the obtuse angle. This strand was carefully straightened on a vise before testing. The intention in obtaining the test specimens in this manner was to determine the strength and properties of the material across the bridges or center connections.

The tests were made on an Olsen Universal Testing Machine of 1000 lb. capacity. The deflections were observed with an extensometer and readings were taken to 1/10,000 of an inch.

The stress-strain curves obtained are characteristio of cold-drawn steels. At your suggestion I am not fixing a value for any of the significant points of deformation.

Yours very truly,

James S. Macgregor



This photograph illustrates the first step taken in securing a specimen for the tensile tests conducted by Prof. Macgregor; a strand cut from the center of a sheet of "Steelcrete" mesh

Illustrating the second step taken in preparing the specimens; observe the part removed

The specimen after having been straightened, and ready for the tensile test, is here shown

It has been presumed that the reader of this handbook is familiar to a certain extent with the characteristic behavior of steel under tensile test. In order that the importance of the conclusions in this chapter may be emphasized, it will be recalled that when a steel specimen is tested in tension to destruction it passes through two well defined and significant stages. During the first stage, the elongations or deformations are comparatively small and increase approximately proportionate to the load. During the second stage there is a plastic yielding of the material which is attended by greatly increased elongations amounting at fracture to many hundred times the whole elongation occurring during the first stage.

Between these two stages there is a well defined point marked by a sudden increase of elongation which is easily noted when the readings are plotted on a chart. (See Curves, pages 222 and 223.) This point is generally termed in the literature of the steel industry, the "yield point" or "commercial elastic limit;" more accurately called, in foreign texts, the "rapidly-breaking-down point;" sometimes erroneously spoken of as the "elastic limit." At this point total failure does not occur, but the warping of the structure which follows ruins it for practical purposes. In the case of a steel which is to be used for reinforced concrete, this point is of great importance as actual failure occurs immediately after it is reached.

It was at one time widely thought among scientists, that steel was perfectly elastic up to a point called the "elastic limit," which we will here call the "theoretical elastic limit" (a point near the "commercial elastic limit" or "yield point" above mentioned). By "perfect elasticity" in the steel was meant that after having been stressed, it would recover its original length if the load were released; that is to say, at the "theoretical elastic limit" a permanent set took place. It is now known, however, that a permanent set can be detected soon after the load is applied, if only instruments precise enough are used.

It was also widely thought, among scientists, that within the "theoretical elastic limit" the stress or unit load was directly proportional to the strain or deformation. That is to say, if the stress and strain readings of a tensile test were plotted, a straight line would be observed up to the "theoretical elastic limit" which would by this definition be the "limit of proportionality."

Many scientists may be cited who state that instead of a straight line a very flat curve will be obtained, if only precise enough instruments are used. In other words, the "limit of proportionality" was found to be reduced with the use of the most precise instruments.

A discussion of the "theoretical elastic limit" is of scientific interest only. It is unquestionable that the "limit of proportionality" is very close to actual facts. It is a point, however, which is commercially impractical to obtain and of doubtful significance. So far as commercial testing is concerned, the significant point which is recognized and taken account of, is the "yield point," the "commercial elastic limit," or "rapidly-breaking-down point." It is this point which is recognized by the Standard Specifications of the Association of American Steel Manufacturers representing practically all of the steel manufacturers in the United States.

It is a fact well known to steel men, that when mild or medium steel is subjected to tensile stress and the material begins to yield plastically (that is to say, the "yield point" or "commercial elastic limit" or "rapidly-breaking-down point" is reached) the unit load temporarily decreases which has the effect of causing the balance beam of a testing machine to drop. Thus the value of the "yield point" is noted at once during a test without recourse to a chart or plotted readings. This temporary drop in the unit load is noted in the diagram as a slight "kink" in the otherwise smooth curve. In the case of a mild steel which has been subjected to the process of cold drawing, as for example, "Steelcrete" mesh, this "kink" above referred to, does not appear, hence, in order to determine the value of the "yield point" in such a case, it is necessary to plot the stress-strain readings. This procedure is characteristic of all cold drawn steels. The behavior of a piece of steel under tensile test may be read at a glance from the plotted stress-strain curve and careful study of the ones hereinafter submitted is invited.

There are many empirical methods of fixing the value of the "yield point" used by the various commercial laboratories throughout the country. It is, however, beyond the scope of this pamphlet to go into an analytical discussion of this phase of the subject.

In order to study the characteristics of the stress-strain diagram indicating the behavior of "Steelcrete" mesh under tensile stress and to determine

the values of the significant points of deformation, the hereinafter described tests were conducted under the supervision of Prof. James S. Macgregor of the Columbia University Laboratories, New York City. The results of these tests will be found in the succeeding pages. The behavior of the specimens during test will be noted at a glance from the curve sheet (pages 222 and 223). The approximately straight portions of the curves in every case, exceed the unit value of 60,000 pounds per square inch, indicating that the "yield point" or "commercial elastic limit" exceeds this value. It will be recalled that the claims for this material, as indicated in this handbook are for a value of the "yield point" of not less than 55,000 pounds per square inch, which is greatly exceeded by the results of these tests.

In order to remove all possible adverse criticism, strict instructions were given Mr. Macgregor to select the specimens from the center of a sheet of "Steelcrete" mesh and include at the central portion of the test specimens a bridge (or center connection between two diamonds). The manner in which the tests specimens were prepared is described in his letter of transmittal on page 216. See also the photographs on page 217, which illustrate the successive steps required. No more exacting tests could be demanded of any steel reinforcing material than are here given. Not only with the motive of satisfying the most difficult specifications are the results of these tests submitted, but also with the end in view of meeting the increasingly critical demands of engineers and designers for detailed information of this character.

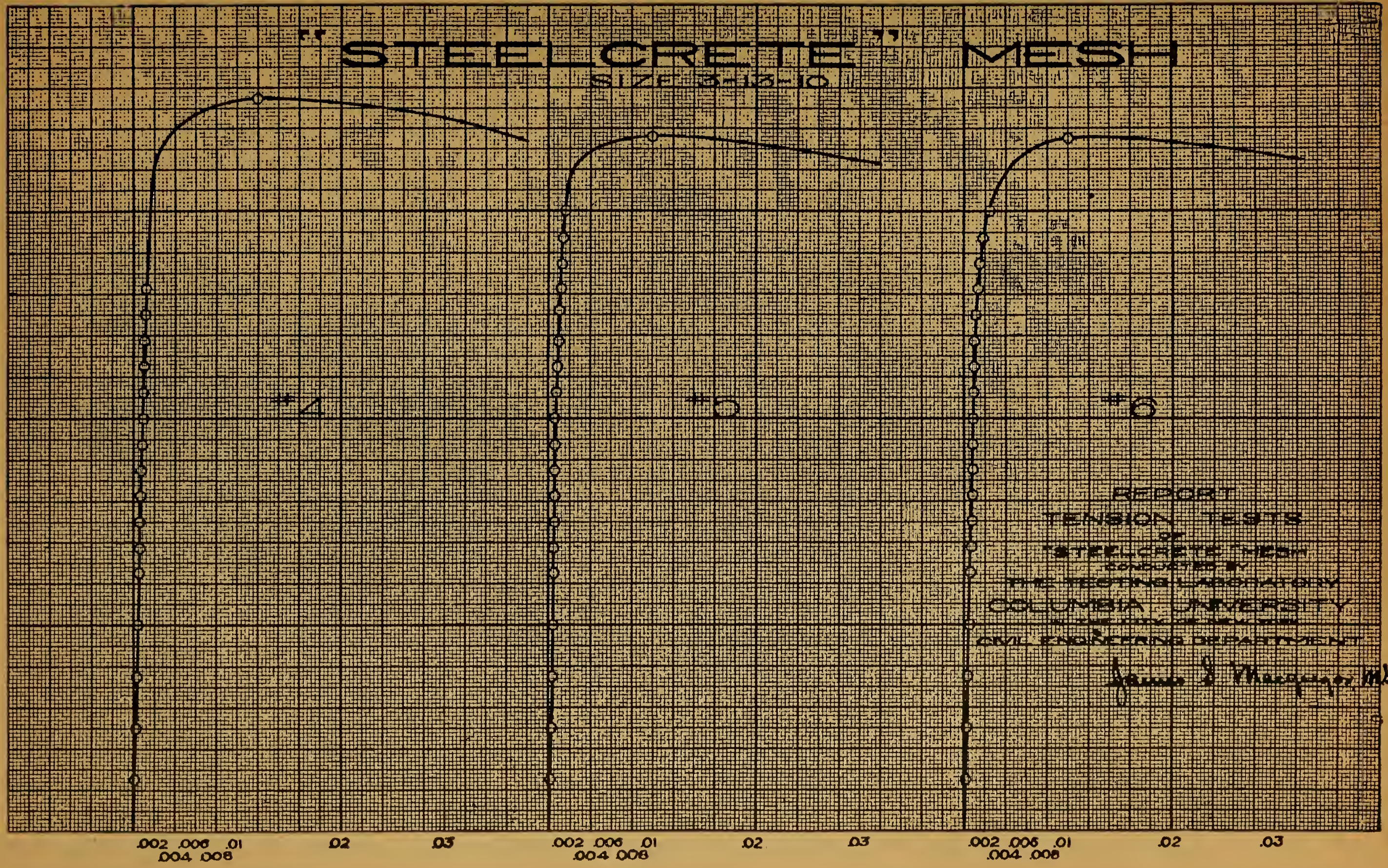
Ductility

DUCTILITY is one of the most important properties of steel required in structural designing. There are two ways of measuring the ductility of steel in common commercial use; (a) the percentage of elongation, (b) the percentage of reduction of area of cross-section.

The percentage of elongation is found by dividing the increase of length after rupture has occurred by the original length. The elongation of a test specimen may be divided into two portions; (a) that part of the elongation which is uniformly distributed over the length; (b) that part of the elongation which occurs in the close vicinity of the section which finally breaks. The accompanying sketch illustrates the "necking-down" action which occurs before rupture. The elongation is measured after rupture has occurred by placing the two ends together and measuring the distance between the original gauge marks.

It will be noted after a cursory inspection of these specimens that the elongation which is locally developed in the vicinity of final rupture, is not the same in all specimens but varies greatly with the diameter or thickness of the test specimen. It requires very little study to see that a piece of steel one inch in diameter will elongate much more in two inches of length adjoining the plane of rupture than a piece one-quarter inch in diameter. In the former case almost all of the two inches represents the length of the "necking-down" portion, while in the latter case only a small part of the two inches represents this "necking-down" portion. The percentage of elongation in the two inches is much greater in the former case than in the latter; although the ductility of the latter steel may be the greater. This principle holds good for all commercial lengths of test specimens which usually run from two to eight inches.


STRESS-STRAIN DIAGRAMS
#1
#2
#3
Unit Elongations in Inches
Unit Load in Pounds
70000
60000
50000
40000
30000
20000
10000
.002 .006 .01
.004 .008
.02
.03


"STEELCRETE" MESH
SIZE 3-13-10
#4
#5
#6
REPORT
TENSION TESTS
OF
"STEELCRETE" MESH
CONDUCTED BY
THE TESTING LABORATORY
COLUMBIA UNIVERSITY
CIVIL ENGINEERING DEPARTMENT
.002 .006 .01
.004 .008
.02
.03

As has been said before, the ultimate elongation in a test specimen of commercial length measures partly the plasticity of a short length at the "necking-down" portion and partly the plasticity of the bar before this drawing out commenced. It is obvious therefore, that in order to compare the ductility of different qualities of steel by the percentage of elongation, the diameter, thickness and shape of the test specimens as well as the gauge lengths should be absolutely the same. It is not always possible to fulfill these conditions as the length and thickness of a commercial test specimen depends primarily on the size and shape of the finished product from which it is taken. It is possible, however, to compare the ductility of test specimens of different diameters, thicknesses and shapes as well as of different lengths by the percentage of the reduction of area at fracture.

"The term 'Reduction of Area' refers to a ruptured specimen and means the diminution in section area per unit of original area --------. Reduction of area, or contraction of area as it is often called, is an index of the ductility of the material and it is generally regarded as a more reliable index than elongation because the ultimate unit elongation is subject to variation with the ratio of the length of the specimen to its diameter, whereas the reduction of area is more constant." Merriman—"Mechanics of Materials." (1905), Page 31.

"The percentage of contraction of area and the quality of the fracture, both very important factors in determining the quality of the metal, are shown with equal accuracy and distinctness with the shorter specimen as with one of greater length." American Society of Testing Materials — 1913.

The percentage of reduction of area is independent of the diameter, thickness, and shape of the test specimen as well as of the length.

While it would be possible to obtain a test specimen of "Steelcrete" mesh of the same length and thickness as is commonly used in steel bars, (i. e., 8 inches in gauge length and $\frac{7}{16}$-inch diameter), such a specimen would be subject to criticism as it does not represent a specimen of a finished product. In order to avoid all possible criticism, the specimens which have been tested were in every case taken from the center of a commercial sheet of mesh. As the thickness, length and shape of the specimen thus obtained would be much less than the above mentioned standard size, the comparative ductility of "Steelcrete" mesh cannot be satisfactorily shown by the method of "percentage of elongation."

Any method of correcting the percentage of elongation of a specimen of "Steelcrete" mesh for the difference in section, shape and length would only be roughly approximate. Moreover, it would not be convincing, as it would require that the percentage of elongation actually obtained be greatly increased in order to make the comparison of any value whatever. The average percentage of elongation of the specimens tested by Prof. Macgregor of the Columbia University Testing Laboratory in New York City and elsewhere described, exceeds the requirements of the Manufacturers Standard Specification (1914) and of the American Society of Testing Materials (1913) for cold twisted square bars used in concrete reinforcement. This figure should be greatly increased in order to make the correction for the size and shape of the specimen. The percentage of reduction of area offers a more satisfactory method of comparison. The percentage of reduction of area of the test specimens of "Steelcrete" mesh investigated by Mr. Macgregor averaged forty per cent, indicating a high degree of ductility.

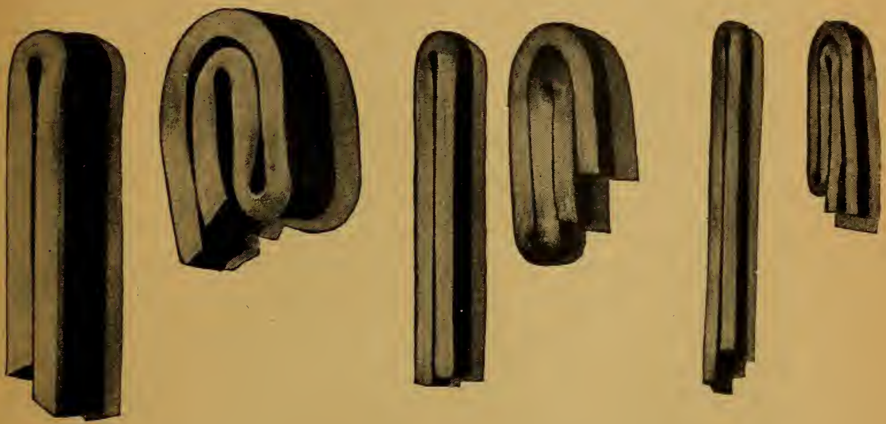
The Character and Significance of the Cold-Bend Test

THE test of the ductility of a malleable metal by bending it cold is the most common and perhaps the most useful of all the tests which can be applied to it. For wrought iron and structural steel this test approaches more nearly to the severe usages of actual practice than does the

tension test with its elastic limit, ultimate strength, elongation, and reduction of area. It is not so easily standardized, however, and it is employed less in America than in Europe, partly because no standard methods and results have been agreed upon here.

"If a sample of wrought iron or steel will, when cold, fold upon itself absolutely, or make the double fold (as shown in accompanying sketch), there can be no doubt of its high quality. When it fractures, however, at intermediate stages of this process, the question of its quality is left in doubt, and some standard limit is required if this test is to be made the basis of acceptance. The great advantage of this test is that it can be made at any time in the shop, without the expense attaching to tension tests, and by the man who uses or makes up the material." Johnson, "The Materials of Construction" (1906), Page 394.

"The cold-bend test is one that has been known from the earliest times and which is constantly used in all mills where wrought iron or steel is produced. The bending of the specimen is generally done by blows of a hammer, although steady pressure is sometimes employed. Notwithstanding that no numerical results are obtained from the cold-bend test, except the final angle of bending, the general information that it gives is of the highest importance, so that it has been said that, if all tests of metals except one were to be abandoned, the cold-bend test should be the one to be retained. In the rolling mill it is used to judge of the purity and quality of the muck bar; in the steel mill it serves to classify and grade the material almost as well as chemical analysis can do, and in the purchase of shape iron it affords a quick and satisfactory method of estimating toughness, ductility, strength and capacity to resist external work." Merriman —"Mechanics of Materials" (1905), Page 439.



The above photographs show the most severe test of ductility and quality to which a piece of steel may be subjected; strands of "Steelcrete" mesh bent flat upon themselves through an angle of 180 degrees without any indication of fracture.

This method of testing is cited by Johnson in "The Materials of Construction" as approaching more nearly to the severe usages of actual practice than does the tension test, with its elastic limit, ultimate strength, elongation and reduction of area.

In referring to the value of the cold-bend test, Professor Merriman states that if all tests of metal except one were abandoned, the cold-bend test should be retained. It should be remembered that this test may be made by anyone at any time in the field.

Even more convincing than anything that has been said heretofore in this chapter in reference to ductility and uniformity of quality is the illustration of the cold-twisted strands of "Steelcrete" mesh here shown. No indication of fracture can be detected. This test, like the one shown on the preceding page can be made in the field by anyone on any commercial sheet of "Steelcrete" mesh

Lap Tests

FLAT sheet reinforcement requires the lapping of adjoining sheets in order to cover a large area, under some forms of construction necessitating a uniform cross-section throughout. Unless otherwise stated, the proper lap of two sheets is eight inches or one diamond, and *may be made at the center of the span* as well as any other place it may occur. The strength of the bond is sufficient then to transfer the full strength of the steel. This has been demonstrated repeatedly wherever "Steelcrete" Mesh has been used.

The following points should be noted about the strength of a lap. Reinforcing steel, if lapped 50 times its diameter, develops the full strength of the steel with a factor of safety of 3. Figured under this formula, a lap of one diamond offers ample strength for this purpose. To further emphasize this fact, the following tests were recently made under our direction to dispel any doubt that may exist:

Materials Testing Laboratory
Carnegie Technical Schools

Tests of Beams
for
The Consolidated Expanded Metal Companies

Pittsburgh, Pa., February, 1911.

Three beams were made in order to test the efficiency of different laps of 3-9-175 "Steelcrete" Expanded Metal.

The beams were 6 x 10 inches by 7 feet, and were reinforced with 9-inch strips of 3-9-175 "Steelcrete" Expanded Metal, at a distance of 1-inch above the bottom of the beam, the lap being at the center of the beam. The proportions of the gravel concrete were: 1, 1½, 4½, and it was machine mixed.

The beams were broken at the age of 26 days with an Olsen Universal Machine, the load being applied at the third points, on a span of 6 feet. See sketch below.

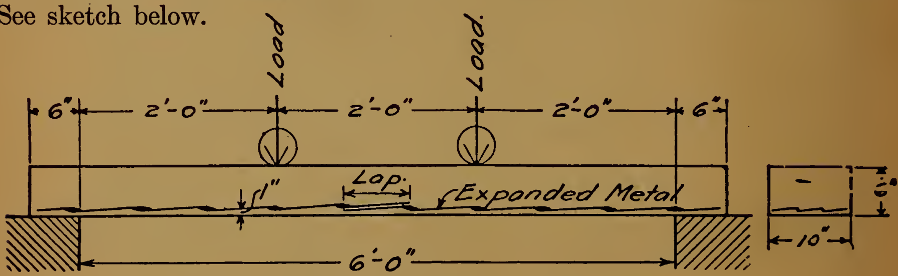


Fig. (13)— Method of construction used in lap tests

A concrete cylinder 8 inches in diameter and 12 inches high was made from each batch of concrete, and the compression strength of these cylinders exceeded 2,000 lbs. per sq. in. at 26 days.

The following are the results of the beam tests:

Beam No.	Lap	Total Load "P" at failure	Cause of Failure
"A1"	4-inch	2945 lbs.	Slipping of steel at lap
"A2"	6-inch	3220 lbs.	Tensile stress in the steel exceeding its elastic limit
"A3"	8-inch	3085 lbs.	Same cause as "A2"

(Signed) F. M. McCULLOUGH,
Ass't Professor in Civil Engineering.

New York City Floor Slab Tests

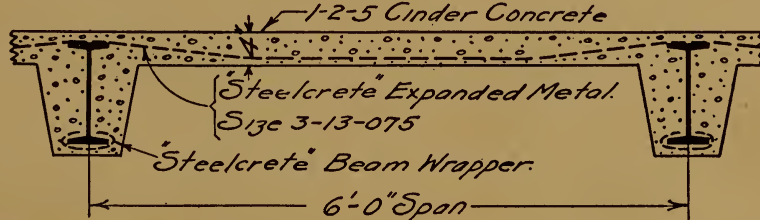
PRIOR to 1914, the building laws of the City of New York required as a precedent condition to the use of any type of reinforcement in cinder concrete that it be submitted to an elaborate load test. This load test was required to be made on a sample floor slab constructed as nearly as possible under the same conditions as would be encountered in a practical application of the system. The following list of approvals made on "Steelcrete" Mesh products under the supervision of the building departments of the City of New York, demonstrate an extensive efficiency of this material as a reinforcing product. The condition of the law called for a permissible use of safe live load value equal to one-tenth the ultimate breaking load of the slabs under test to destruction.

Any variation in span, thickness of slab and size of reinforcement required a separate load test. For this reason the five tests herein given were conducted.

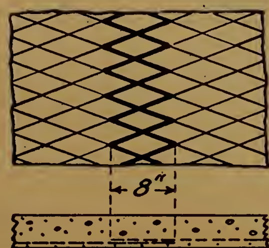
The materials used were Lehigh Portland Cement, ordinary commercial sand, and steam hard coal cinders in the proportions of 1:2:5, respectively. The slabs were approximately 30 days old when tested. The loads actually sustained were in every case ten times the load for which it was approved. A distinguishing feature of these tests consists in that the reinforcement was not a continuous sheet over the whole span, but was made by lapping the ends of two sheets of mesh (8) inches or one diamond. This lap was made at the center of the span where the greatest stress would come upon it. This unusual test was made by the authorities of the Building Department of Greater New York in order to comply with that portion of the code which required that the reinforcement should be laid as nearly as possible to the same conditions as might be encountered in practice. Inasmuch as it was desired to use this mesh in continuous work, all requirements would be met in the tests as made. The result of this feature of the test was a strong confirmation of the assertions of this company in this respect. In every instance the slabs were tested to destruction, and in every instance the failure was in the steel

"Steelcrete" Reinforcement.

SYSTEM 101



This system was tested Oct. 18, 1911 for the Bureaus of Bldgs. of the Five Boroughs of Greater New York and approved Nov. 6,-1911 for live loads up to and including 175 lbs. per sq. ft. when constructed as tested. The tests having been made with an 8" lap at the center of the span, it will be sufficient to allow the lap to be made wherever it may occur in the construction.



DETAIL OF REINFORCEMENT
SHOWING AN 8" LAP.
(one diamond)

FIRE PROOF FLOOR SYSTEM.

Reinforced with "Steelcrete" MESH.

THE EXPANDED METAL ENGINEERING CO.
NEW YORK AGENTS

THE CONSOLIDATED EXPANDED METAL COS. MNFRS.
NEW YORK. PITTSBURGH.

outside of the lap. The lap remained intact and there was not the slightest indication of failure. The sheets of expanded metal were wired together at the lap every three feet in accordance with standard practice. This insures the correct position of the reinforcement during the pouring of the concrete.

The following additional approvals were obtained after test. The details of construction were the same as shown on preceding page.

Size of Mesh	Span	Thickness of Slab	Live Load Approved Lbs. per sq. ft.	Ultimate Breaking Load of Slab Tested Lbs. per sq. ft.
3-13-125	6′ 0″	4″	328	3280
3-13-10	8′ 0″	4″	94	940
3-13-10	8′ 0″	5″	200	2000
3-13-125	8′ 0″	4″	120	1200

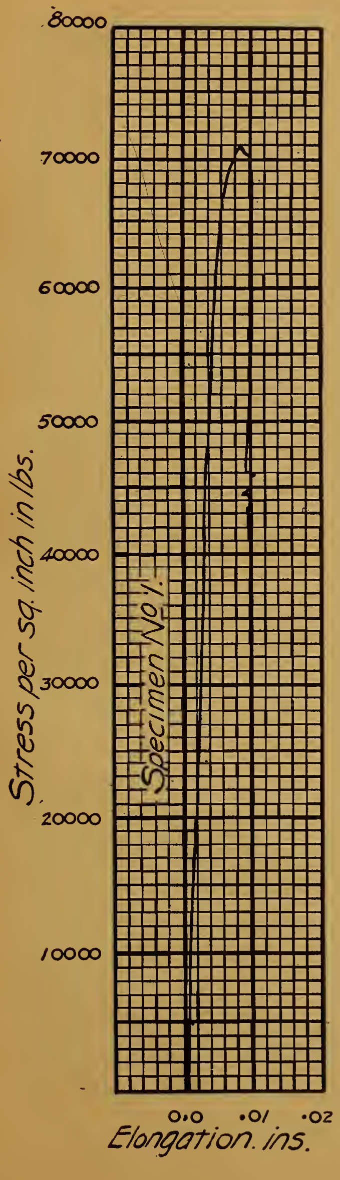
It is interesting, at the same time instructive, to compare the results of these tests with the safe values of the live loads given in the tables computed under the common formulas in general use.

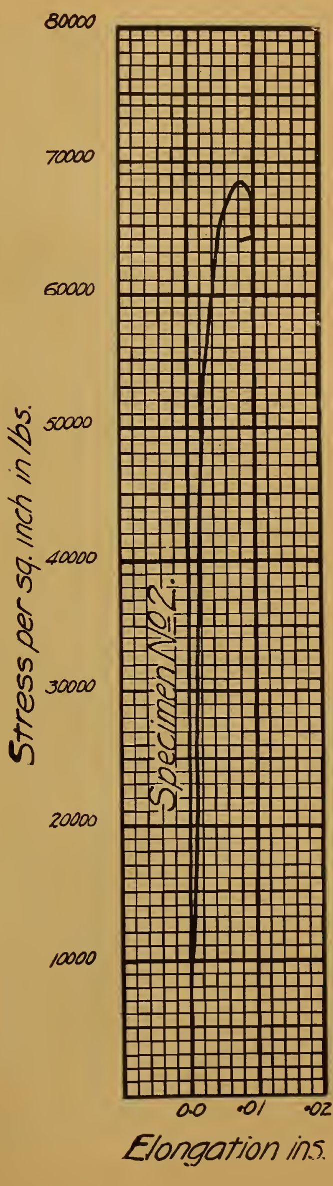
Tests Made by the Olsen Testing Machine Company of Philadelphia, Pa.

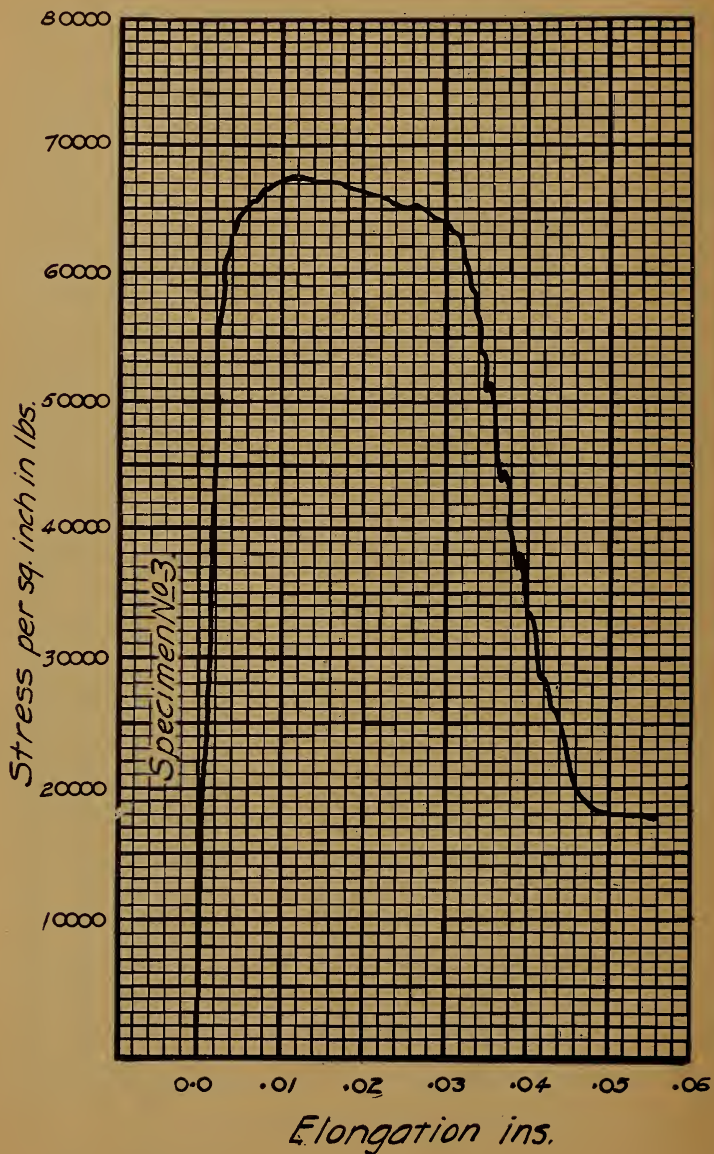
No better method of testing a material is to be found than that offered by the autographic recording machine. On account of the small size of specimens which are required to be tested, in the case of "Steelcrete" meshes, the commonly used autographic machines are not adaptable. Such machines are designed to record graphically a standard size test specimen about ½-inch diameter and 8 inches long. A strand of expanded metal is about 2 inches long and of comparatively small sectional area. Recently, the Olsen Testing Machine Co., completed a testing machine capable of recording autographically the curve of a test specimen such as is obtainable in a strand of "Steelcrete" mesh. The very interesting results given below substantiate the findings of Professor Macgregor's tests of the Columbia University Testing Laboratories hereinbefore given. Strands of commercial expanded metal were used in every case.

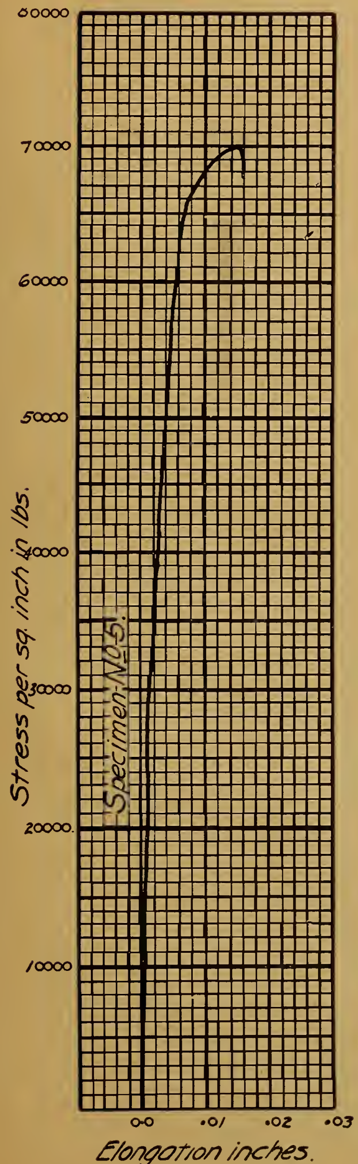
Summary of Tests Conducted by The Tinius Olsen Testing Machine Co., Philadelphia, Pa. April 26, 1918

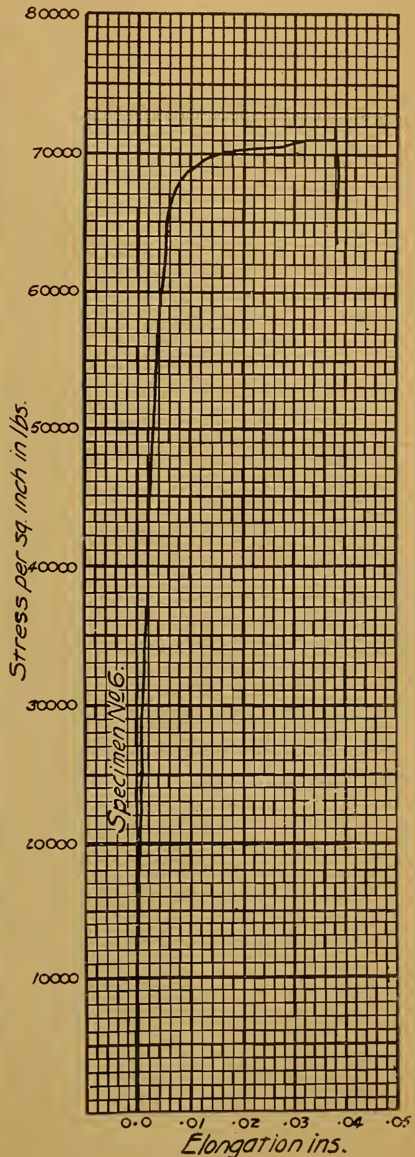
Specimen Number	Size of test specimen in inches	Area in sq. in.	Broke at in lbs.	Ultimate strength in lbs. per sq. in.
1	0.112 x 0.086	.00963	684	71,000
2	0.112 x 0.089	.00996	681	68,300
3	0.117 x 0.090	.01593	1080	67,800
4	....	......	....	......
5	0.163 x 0.137	.0223	1560	70,000
6	0.191 x 0.137	.0261	1848	70,600


80000
70000
60000
50000
40000
30000
20000
10000
Stress per sq. inch in lbs.
Specimen No 1.
0.0
.01
.02
Elongation. ins.


80000
70000
60000
50000
40000
30000
20000
10000
Stress per sq. inch in lbs.
Specimen No 2.
0.0
.01
.02
Elongation ins.


80000
70000
60000
50000
40000
30000
20000
10000
Stress per sq. inch in lbs.
Specimen No 3
0·0
·01
·02
·03
·04
·05
·06
Elongation ins.


80000
70000
60000
50000
40000
30000
20000.
10000
Stress per sq. inch in lbs.
Specimen No 5.
0-0
•01
•02
•03
Elongation inches.


80000
70000
60000
50000
40000
30000
20000
10000
Stress per sq. inch in lbs.
Specimen No 6.
0.0
.01
.02
.03
.04
.05
Elongation ins.

Cubic Feet of Concrete per Lineal Foot of Rectangular Beams and Columns.

Size Inches.	4"	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36"
8"	.22	.33	.44														
10	.28	.42	.56	.70													
12	.33	.50	.67	.83	1.00												
14	.39	.58	.78	.97	1.17	1.36											
16	.44	.67	.89	1.11	1.33	1.56	1.78										
18	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25									
20	.56	.83	1.11	1.39	1.67	1.95	2.22	2.50	2.78								
22	.61	.92	1.22	1.53	1.83	2.14	2.44	2.75	3.05	3.36							
24	.67	1.00	1.33	1.67	2.00	2.33	2.67	3.00	3.33	3.67	4.00						
26	.72	1.08	1.44	1.81	2.17	2.53	2.89	3.25	3.61	3.97	4.33	4.70					
28	.78	1.17	1.56	1.94	2.33	2.72	3.11	3.50	3.89	4.28	4.67	5.06	5.45				
30	.83	1.25	1.67	2.08	2.50	2.92	3.33	3.75	4.17	4.58	5.00	5.42	5.83	6.25			
32	.89	1.33	1.78	2.22	2.67	3.11	3.56	4.00	4.45	4.89	5.33	5.78	6.22	6.67	7.11		
34	.94	1.42	1.89	2.36	2.83	3.30	3.78	4.25	4.73	5.20	5.67	6.14	6.61	7.08	7.56	8.03	
36	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00
38	1.06	1.58	2.11	2.64	3.17	3.70	4.22	4.75	5.28	5.81	6.33	6.86	7.39	7.91	8.44	8.97	9.50
40	1.11	1.67	2.22	2.78	3.33	3.89	4.44	5.00	5.56	6.12	6.67	7.22	7.78	8.34	8.89	9.44	10.00
42	1.17	1.75	2.33	2.92	3.50	4.09	4.67	5.25	5.83	6.42	7.00	7.59	8.17	8.75	9.33	9.91	10.50
44	1.22	1.83	2.44	3.06	3.67	4.28	4.89	5.50	6.11	6.72	7.33	7.95	8.56	9.17	9.78	10.39	11.00
46	1.28	1.92	2.56	3.20	3.83	4.47	5.11	5.75	6.39	7.03	7.67	8.31	8.95	9.58	10.22	10.85	11.50
48	1.33	2.00	2.67	3.33	4.00	4.67	5.33	6.00	6.67	7.33	8.00	8.67	9.33	10.00	10.67	11.33	12.00
50"	1.39	2.08	2.78	3.47	4.17	4.86	5.56	6.25	6.94	7.64	8.33	9.03	9.72	10.42	11.11	11.80	12.50

Weight of Concrete in Pounds per Lineal Foot of Rectangular Beams and Columns.

Size Inches.	4"	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36"
8"	33	50	66														
10	42	63	84	105													
12	50	75	101	126	150												
14	59	87	117	147	174	204											
16	66	101	132	168	201	234	264										
18	75	113	150	189	225	273	300	338									
20	84	125	168	210	249	293	336	375	420								
22	92	138	183	228	276	321	366	413	456	504							
24	101	150	201	249	300	335	402	450	498	551	600						
26	108	162	216	270	324	380	432	488	540	596	648	705					
28	117	176	234	291	351	408	468	525	582	642	702	759	816				
30	125	188	249	312	375	438	498	563	624	687	750	813	876	938			
32	134	200	267	333	399	467	534	600	666	734	798	867	933	1001	1068		
34	141	213	282	354	426	495	564	638	708	780	852	921	990	1062	1128	1205	
36	150	225	300	375	450	525	600	675	750	825	900	975	1050	1125	1200	1275	1350
38	159	237	318	396	474	555	636	713	792	872	948	1029	1110	1187	1272	1346	1425
40	167	251	333	417	501	584	666	750	834	918	1002	1083	1167	1251	1332	1416	1500
42	176	263	351	438	525	614	702	788	876	963	1050	1139	1227	1313	1404	1487	1575
44	183	275	366	459	549	642	732	825	918	1008	1098	1193	1284	1376	1464	1559	1650
46	192	288	384	480	576	671	768	863	960	1055	1152	1247	1341	1437	1536	1628	1725
48	200	300	399	501	600	701	798	900	1002	1100	1200	1301	1401	1500	1596	1700	1800
50"	209	312	417	522	624	729	834	938	1044	1146	1248	1355	1458	1563	1668	1770	1875

WOODEN COLUMNS.

Safe Loads, in Tons, for Square White Pine Wooden Columns.

Height in Feet.	Side of Square Column in Inches.								
	4"	6	8	10	12	14	16	18	20."
4'	6.4	17.8	35.0	57.2	84.6	117.0	154.6	196.8	244.2
6	4.4	14.3	30.2	51.6	78.7	110.0	147.3	189.3	237.2
8	3.0	11.1	25.4	45.7	71.4	102.8	140.0	181.7	229.0
10	2.2	8.6	21.1	39.7	64.3	94.9	130.5	171.4	218.4
12	1.6	6.8	17.5	34.2	57.1	86.0	121.0	161.3	207.2
14	1.2	5.4	14.5	29.4	50.5	77.6	111.2	150.1	194.9
16	1.0	4.4	12.2	25.3	44.5	70.0	101.6	139.2	182.6
18	.8	3.6	10.2	21.8	39.2	62.7	92.7	128.2	170.2
20	.6	3.0	8.7	18.9	34.6	56.3	84.3	118.2	158.5
22		2.6	7.5	16.5	30.7	51.0	76.7	108.6	147.3
24		2.2	6.5	14.5	27.2	45.6	69.7	100.0	136.6
26		1.9	5.6	12.8	24.3	41.4	63.3	91.8	126.8
28		1.6	5.0	11.3	21.8	37.2	57.7	84.6	117.6
30		1.5	4.4	10.1	19.6	33.9	52.9	77.8	108.9
32		1.3	3.9	9.0	17.6	30.5	48.4	71.7	101.1
34		1.1	3.5	8.2	16.0	27.7	44.5	66.4	93.8
36		1.0	3.2	7.4	14.5	25.5	40.9	61.3	87.4
38		.9	2.9	6.7	13.3	23.5	37.5	56.8	81.2
40		.8	2.6	6.1	12.2	21.6	34.7	52.6	75.6
42			2.4	5.6	11.2	19.9	32.2	49.0	70.8
44			2.2	5.1	10.3	18.5	30.0	45.6	66.1
46			2.0	4.7	9.5	17.1	27.7	42.6	61.9
48			1.8	4.4	8.8	16.0	25.8	39.8	58.0
50			1.7	4.2	8.2	14.8	24.1	37.2	54.3
52					7.6	14.0	22.7	34.7	51.0
54					7.1	13.2	21.3	32.8	48.2
56					6.6	12.3	19.9	30.8	45.4
58					6.2	11.5	18.8	28.8	42.8
60'					5.9	10.6	17.6	27.4	40.3

Note:—

Oak columns will carry loads 15 per. cent greater than given above.

Southern Yellow Pine will carry loads 40 per cent greater than given above.

The loads given in the table are for columns in permanent structures.

For columns in temporary structures add 25 per cent to the above loads.

WOODEN BEAMS.

Table of safe quiescent loads in pounds for horizontal rectangular beams of White Pine or Spruce, one inch broad, supported at both ends & uniformly distributed load.

Span in Feet	Depth of Beam in Inches. 6"	8	10	12	14	16"
5'	800	1420	2220	3200	4350	5690
6	670	1180	1850	2670	3630	4740
7	570	1010	1590	2280	3110	4060
8	500	890	1290	2000	2720	3560
9	440	790	1210	1780	2420	3160
10	400	710	1110	1600	2180	2840
11	360	650	1010	1450	1980	2590
12	330	590	930	1330	1810	2370
13	310	550	850	1230	1680	2190
14	290	510	790	1140	1560	2030
15	270	470	740	1070	1450	1900
16	250	440	690	1000	1360	1780
17	230	420	650	940	1280	1670
18	220	400	620	890	1210	1580
19	210	380	590	840	1150	1500
20	200	360	560	800	1090	1420
21	190	340	530	760	1040	1350
22	180	320	500	730	990	1290
23	170	300	480	700	950	1230
24	160	290	460	670	910	1180
25	160	280	440	640	870	1130
26	150	270	420	610	840	1090
27	150	260	400	590	810	1050
28	140	250	390	570	780	1010
29	140	250	380	550	750	980
30	130	240	370	530	730	950

This table has been calculated for extreme fibre stress of 1000 lbs. per square inch, being one-sixth the breaking stress, ordinary building timber of fair quality.

Oak and Yellow Pine will carry a load one-fourth greater.

When more accuracy is required, the weight of the beam itself must be deducted.

Care must be taken to let the beams rest for a sufficient distance on their supports to guard against crushing at the ends, especially in placing very heavy loads upon short but deep and strong beams.

LUMBER MEASURE.

Size.	Length in Feet.												
	6	8	10	12	14	16	18	20	22	24	26	28	30
1"x4"	2	2.7	3.3	4	4.7	5.3	6	6.7	7.3	8	8.7	9.3	10
1x6	3	4.0	5.0	6	7.0	8.0	9	10.0	11.0	12	13.0	14.0	15
1x8	4	5.3	6.7	8	9.3	10.7	12	13.3	14.7	16	17.3	18.7	20
1x10	5	6.7	8.3	10	11.7	13.3	15	16.7	18.3	20	21.7	23.3	25
1x12	6	8.0	10.0	12	14.0	16.0	18	20.0	22.0	24	26.0	28.0	30
2x4	4	5.3	6.7	8	9.3	10.7	12	13.3	14.7	16	17.3	18.7	20
2x6	6	8.0	10.0	12	14.0	16.0	18	20.0	22.0	24	26.0	28.0	30
2x8	8	10.7	13.3	16	18.7	21.3	24	26.7	29.3	32	34.7	37.3	40
2x10	10	13.3	16.7	20	23.3	26.7	30	33.3	36.7	40	43.3	46.7	50
2x12	12	16.0	20.0	24	28.0	32.0	36	40.0	44.0	48	52.0	56.0	60
4x4	8	10.7	13.3	16	18.7	21.3	24	26.7	29.3	32	34.7	37.3	40
4x6	12	16.0	20.0	24	28.0	32.0	36	40.0	44.0	48	52.0	56.0	60
4x8	16	21.3	26.7	32	37.3	42.7	48	53.3	58.7	64	69.3	74.7	80
4x10	20	26.7	33.3	40	46.7	53.3	60	66.7	73.3	80	86.7	93.3	100
4x12	24	32.0	40.0	48	56.0	64.0	72	80.0	88.0	96	104.0	112.0	120
6x6	18	24.0	30.0	36	42.0	48.0	54	60.0	66.0	72	78.0	84.0	90
6x8	24	32.0	40.0	48	56.0	64.0	72	80.0	88.0	96	104.0	112.0	120
6x10	30	40.0	50.0	60	70.0	80.0	90	100.0	110.0	120	130.0	140.0	150
6x12	36	48.0	60.0	72	84.0	96.0	108	120.0	132.0	144	156.0	168.0	180
8x8	32	42.7	53.3	64	74.7	85.3	96	106.7	117.3	128	138.7	149.3	160
10x10	50	66.7	83.3	100	116.7	133.3	150	166.7	183.3	200	216.7	233.3	250
12x12	72	96.0	120.0	144	168.0	192.0	216	240.0	264.0	288	312.0	336.0	360
12x14	84	112.0	140.0	168	196.0	224.0	252	280.0	308.0	336	364.0	392.0	420
14x14	98	130.7	163.3	196	228.7	261.3	294	326.7	359.3	392	424.7	457.3	490
16"x16"	128	170.7	213.3	256	298.7	341.3	384	426.7	469.3	512	554.7	597.3	640

Note— One Foot Board Measure = 12"x12"x1" = 144 cubic inches = $\frac{1}{12}$ cubic foot.

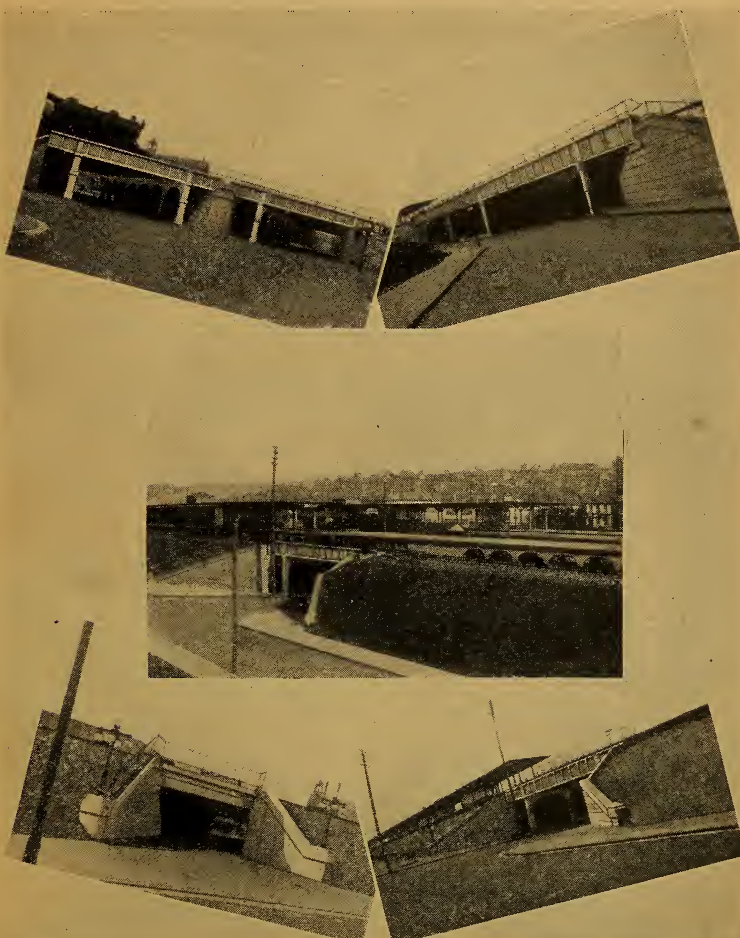
Proportions for Mixing Concrete

Mixtures			Required for 1 Cubic Yard Rammed Concrete								
			Stone 1-in. and Under, Dust Screened Out			Stone 2½-in. and Under, Dust Screened Out			Gravel ¾-in. and Under		
Cement	Sand	Stone	Cement Bbls.	Sand Cu. Yds.	Stone Cu. Yds.	Cement Bbls.	Sand Cu. Yds.	Stone Cu. Yds.	Cement Bbls.	Sand Cu. Yds.	Gravel Cu. Yds.
1	1.0	2.0	2.57	0.39	0.78	2.63	0.40	0.80	2.30	0.35	0.74
1	1.0	2.5	2.29	0.35	0.70	2.34	0.36	0.89	2.10	0.32	0.80
1	1.0	3.0	2.06	0.31	0.94	2.10	0.32	0.96	1.89	0.29	0.86
1	1.0	3.5	1.84	0.28	0.98	1.88	0.29	1.00	1.71	0.26	0.91
1	1.5	2.5	2.05	0.47	0.78	2.09	0.48	0.80	1.83	0.42	0.73
1	1.5	3.0	1.85	0.42	0.84	1.90	0.43	0.87	1.71	0.39	0.78
1	1.5	3.5	1.72	0.39	0.91	1.74	0.40	0.93	1.57	0.36	0.83
1	1.5	4.0	1.57	0.36	0.96	1.61	0.37	0.98	1.46	0.33	0.88
1	1.5	4.5	1.43	0.33	0.98	1.46	0.33	1.00	1.34	0.31	0.91
1	2.0	3.0	1.70	0.52	0.77	1.73	0.53	0.79	1.54	0.47	0.73
1	2.0	3.5	1.57	0.48	0.83	1.61	0.49	0.85	1.44	0.44	0.77
1	2.0	4.0	1.46	0.44	0.89	1.48	0.45	0.90	1.34	0.41	0.81
1	2.0	4.5	1.36	0.42	0.93	1.38	0.42	0.95	1.26	0.38	0.86
1	2.0	5.0	1.27	0.39	0.97	1.29	0.39	0.98	1.17	0.36	0.89
1	2.5	3.5	1.45	0.55	0.77	1.48	0.56	0.79	1.32	0.50	0.70
1	2.5	4.0	1.35	0.52	0.82	1.38	0.53	0.84	1.24	0.47	0.75
1	2.5	4.5	1.27	0.48	0.87	1.29	0.49	0.88	1.16	0.44	0.80
1	2.5	5.0	1.19	0.46	0.91	1.21	0.46	0.92	1.10	0.42	0.83
1	2.5	5.5	1.13	0.43	0.94	1.15	0.44	0.96	1.03	0.39	0.86
1	2.5	6.0	1.07	0.41	0.97	1.07	0.41	0.98	0.98	0.37	0.89
1	3.0	4.0	1.26	0.58	0.77	1.28	0.58	0.78	1.15	0.52	0.72
1	3.0	4.5	1.18	0.54	0.81	1.20	0.55	0.82	1.09	0.50	0.75
1	3.0	5.0	1.11	0.51	0.85	1.14	0.52	0.87	1.03	0.47	0.78
1	3.0	5.5	1.06	0.48	0.89	1.07	0.49	0.90	0.97	0.44	0.81
1	3.0	6.0	1.01	0.46	0.92	1.02	0.47	0.93	0.92	0.42	0.84
1	3.0	6.5	0.96	0.44	0.95	0.98	0.44	0.96	0.88	0.40	0.87
1	3.0	7.0	0.91	0.42	0.97	0.92	0.42	0.98	0.84	0.38	0.89
1	3.5	5.0	1.05	0.56	0.80	1.07	0.57	0.82	0.96	0.50	0.76
1	3.5	5.5	1.00	0.53	0.84	1.02	0.54	0.85	0.92	0.48	0.78
1	3.5	6.0	0.95	0.50	0.87	0.97	0.51	0.89	0.88	0.46	0.80
1	3.5	6.5	0.92	0.49	0.91	0.93	0.49	0.92	0.83	0.44	0.82
1	3.5	7.0	0.87	0.47	0.93	0.89	0.47	0.95	0.80	0.43	0.85
1	3.5	7.5	0.84	0.45	0.96	0.86	0.45	0.98	0.76	0.41	0.87
1	3.5	8.0	0.80	0.42	0.97	0.82	0.43	1.01	0.73	0.39	0.89
1	4.0	6.0	0.90	0.55	0.82	0.92	0.56	0.84	0.83	0.51	0.77
1	4.0	6.5	0.87	0.53	0.85	0.88	0.53	0.87	0.80	0.49	0.79
1	4.0	7.0	0.83	0.51	0.89	0.84	0.51	0.90	0.77	0.47	0.81
1	4.0	7.5	0.80	0.49	0.91	0.81	0.50	0.93	0.73	0.44	0.83
1	4.0	8.0	0.77	0.47	0.93	0.78	0.48	0.95	0.71	0.43	0.86
1	4.0	8.5	0.74	0.45	0.95	0.76	0.46	0.98	0.68	0.42	0.88
1	4.0	9.0	0.71	0.43	0.97	0.73	0.44	1.01	0.65	0.40	0.89

1 barrel cement and 2 barrels of sand will cover 99 sq. ft. of floor 1-in. thick.
1 barrel cement and 1 barrel of sand will cover 68 sq. ft. of floor 1-in. thick.

Square and Round Steel Bars

Side or Diameter Inches	Pounds per Linear Foot		Area in Square Inches		Circumference of Round Bar Sq. In.	Side or Diameter Inches
	Square	Round	Square	Round		
1/16	.013	.010	.0039	.0031	.1963	1/16
1/8	.053	.042	.0156	.0123	.3927	1/8
3/16	.119	.094	.0352	.0276	.5890	3/16
1/4	.212	.167	.0625	.0491	.7854	1/4
5/16	.333	.261	.0977	.0767	.9817	5/16
3/8	.478	.375	.1406	.1104	1.1781	3/8
7/16	.651	.511	.1914	.1503	1.3744	7/16
1/2	.850	.667	.2500	.1963	1.5708	1/2
9/16	1.076	.845	.3164	.2485	1.7671	9/16
5/8	1.328	1.043	.3906	.3068	1.9635	5/8
11/16	1.608	1.262	.4727	.3712	2.1593	11/16
3/4	1.913	1.502	.5625	.4418	2.3562	3/4
13/16	2.245	1.763	.6602	.5185	2.5525	13/16
7/8	2.603	2.044	.7656	.6013	2.7489	7/8
15/16	2.989	2.347	.8789	.6903	2.9452	15/16
1	3.400	2.670	1.0000	.7854	3.1416	1
1 1/16	3.833	3.014	1.1289	.8866	3.3379	1 1/16
1 1/8	4.303	3.379	1.2656	.9940	3.5343	1 1/8
1 3/16	4.795	3.766	1.4102	1.1075	3.7306	1 3/16
1 1/4	5.312	4.173	1.5625	1.2272	3.9270	1 1/4
1 5/16	5.857	4.600	1.7227	1.3530	4.1233	1 5/16
1 3/8	6.428	5.049	1.8906	1.4849	4.3197	1 3/8
1 7/16	7.026	5.518	2 0664	1.6230	4.5160	1 7/16
1 1/2	7.650	6.008	2.2500	1.7671	4.7124	1 1/2
1 9/16	8.301	6.520	2.4414	1.9175	4.9087	1 9/16
1 5/8	8.978	7.051	2.6406	2.0739	5.1051	1 5/8
1 11/16	9.682	7.604	2.8477	2.2365	5.3014	1 11/16
1 3/4	10.41	8.178	3.0625	2.4053	5.4978	1 3/4
1 13/16	11.17	8.773	3.2852	2 5802	5.6941	1 13/16
1 7/8	11.95	9.388	3.5156	2.7612	5.8905	1 7/8
1 15/16	12.76	10.02	3.7539	2.9483	6.0868	1 15/16
2	13.60	10.68	4.0000	3.1416	6.2832	2



Steel railroad bridges encased in concrete are submitted to undulating strains and vibrations which would prove destructive to the surrounding concrete if were not properly bonded. If cracks are obtained it makes unsightly work and puts the stamp of deterioration and decay on work which should be extolled and referred to because of its permanence. Steelcrete mesh is designed to take care of the very stresses here encountered. The photographs show the work done by the Pennsylvania Railroad on grade crossings in and about Wilkinsburg, Penna., which cost ran into several millions of dollars. Upwards of 100,000 sq. ft. of Steelcrete Mesh was used to properly bond the concrete.

"Steelcrete" Floor Binder

FLOOR binder is designed to meet the needs of the tile and terrazzo industry for temperature reinforcement in the filler coat. Placing reinforcement in approximately a ⅞-inch coat of cement mortar requires that it should be a perfectly flat sheet. "Steelcrete" Floor Binder insures this and at the same time provides a real reinforcement against cracks due to expansion and contraction.

If real reinforcement is not needed, leave it out altogether.

Floor binder will also answer as a light temperature reinforcement to place near the surface of retaining walls, sidewalks, columns, and concrete beams.

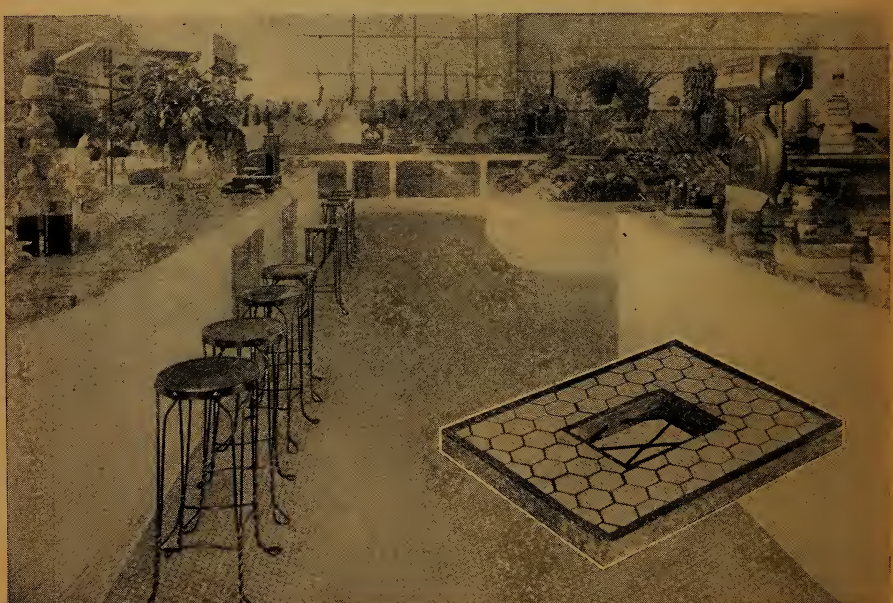
1 — Manufactured in No. 16 gauge with a two-inch diamond opening, complying with specifications of the United States Government.

2 — Sheets 5′-0″ x 8′-8″— 15 sheets per bundle.

3 — Weight — twenty pounds per hundred square feet.

4 — Shipped only in full bundles.

5 — When ordering, simply call for "Steelcrete" Floor Binder. It has no other designation.



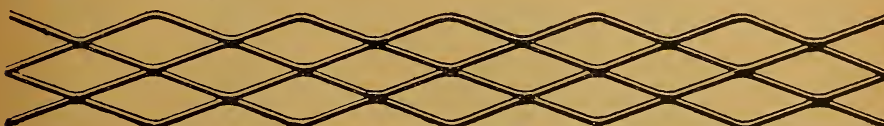
A reinforcement against cracks

"Steelcrete" Beam Wrapper

1 — Beam Wrapper as shown below will serve as a concrete binder for the lower flange of I-Beams of all sizes up to 24 inches. This material can be readily placed and will cost from one-third to one-half the price of ordinary patented materials for the same purpose.

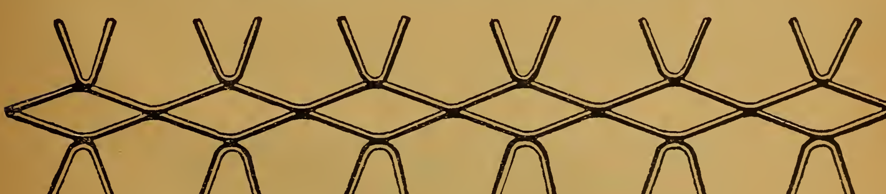
2 — Furnished in 3-inch Diamond Mesh, two diamonds wide, 8′-8″ lengths as shown on cuts below. Its weight is twenty pounds per hundred square feet. When requested it can be shipped with outside strands cut as shown in second instruction below.

3 — When ordering, simply call for "Steelcrete" Beam Wrapper. It has no other designation.



The above shows the way the material is received

It is then cut as shown with a pair of tinner's snips or shears



The strands are then pulled out

And the material applied to the soffit of the beam

Metal Lath

We manufacture a complete line of metal lath. We carry all standard sizes adaptable to all classes of work. Detailed data is ready for distribution and will be mailed on request. The following list of sizes is given here for quick reference:

"Steelcrete" Metal Lath

Designation	Ptd. Weight per Sq. Yd. in Bundle	Size of Sheet	Sheets in Bundle	Sq. Yd. in Bundle	Weight per Bundle
*22-P	4.37	24″ x 96″	10	17.77	77.65
24-F	3.40	24″ x 96″	15	26.66	90.67
25-F	3.00	24″ x 96″	15	26.66	80.00
26-F	2.55	24″ x 96″	15	26.66	68.00
27-F	2.33	24″ x 96″	15	26.66	62.22
24-H	2.90	28″ x 96″	14	29.00	84.10
26-H	2.20	28″ x 96″	14	29.00	63.80

*Special Post Office Lath $\frac{3}{32}$″ Strand.

The above laths can be furnished in the following:

1—Painted black.

2—Cut from galvanized sheet (add .4 lb. to the above weights for this kind of lath).

3—Copper-bearing steel painted red (acid resisting).

Cut showing "Steelcrete" Diamond Lath

Safety Guard Mesh

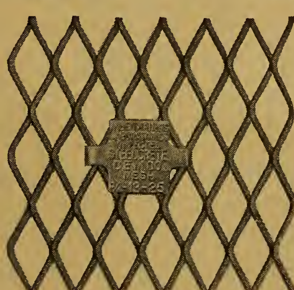
Expanded Metal serves a wide field in the safety guard industry. Our various states have adopted laws making it necessary to protect all moving parts of machinery. For this purpose, no better material can be had than expanded metal of small diamond meshes. The following tables give the sizes available:

Designation	Gauge of Sheet	Width of Diamond Opening	Length of Diamond Opening	Approximate Weight per sq. ft. in Lbs.	Standard Size of Sheet
Standard Meshes for 95% of all Requirements					
½″ 18	18	.43″	1.2″	.74	3′ 0″ x 8′ 8″ 6′ 0″ x 8′ 8″
¾″-13-25	13	.95″	2.0″	.80	6′ 0″ x 8′ 0″
1½″-13-20	13	1.36″	3.0″	.60	4′ 0″ x 8′ 0″
2″ -13-15	13	1.82″	4.0″	.50	5′ 0″ x 8′ 0″
Heavy Meshes for Exceptional Uses					
¾″ 9	9	.95″	2.0″	1.80	4′ 0″ x 8′ 0″
1½″ 9	9	1.36″	3.0″	1.28	6′ 0″ x 8′ 0″
2″ 9	9	1.82″	4.0″	.90	4′ 0″ x 8′ 0″

In every instance the width of sheet is measured along the shorter dimension of the diamond. The length of the sheet is measured along the longer dimension of the diamond.

Underwriters' "Steelcrete"

Approved and Inspected by Underwriters' Laboratories



The Protective Screening Used in Machine Guards, Shop Partitions, Window Guards

Used by Manufacturers of Machinery — Sheet Metal Workers — Ornamental Iron Workers — Mill Owners

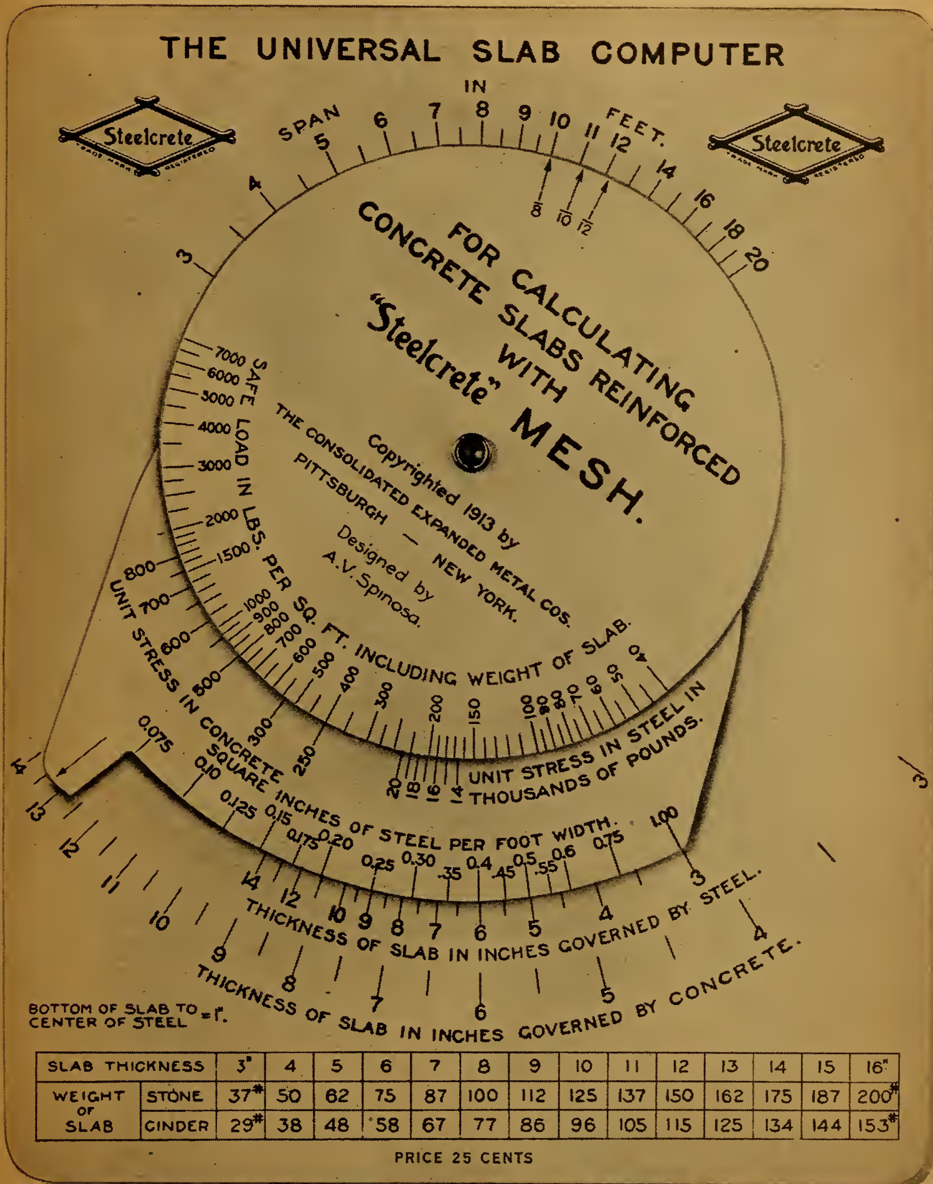
Standard Sizes of Steelcrete Meshes Adaptable to Concrete Reinforcing

Designation	Sectional Area in sq. in. per ft. Width	Weight in Pounds per sq. ft.	Width of Standard Sheet	Number of Sheets in a Standard Bundle
*3-13-075	.075	.27	6′ 0″	10
*3-13-10	.10	.37	6′ 9″	7
*3-13-125	.125	.46	5′ 3″	7
*3- 9-15	.15	.55	7′ 0″	5
*3- 9-175	.175	.64	6′ 0″	5
*3- 9-20	.20	.73	5′ 3″	5
*3- 9-25	.25	.92	4′ 0″	5
*3- 9-30	.30	1.10	7′ 0″	2
*3- 9-35	.35	1.28	6′ 0″	2
3- 6-40	.40	1.46	7′ 0″	2
3- 6-45	.45	1.65	6′ 3″	2
3- 6-50	.50	1.83	5′ 9″	2
3- 6-55	.55	2.01	5′ 3″	2
3- 6-60	.60	2.19	4′ 9″	2
†3- 1-75	.75	2.74	5′ 9″	1
†3- 1-100	1.00	3.63	4′ 3″	1

All of the above have a diamond opening 3″ x 8″.

All items listed above are furnished in 8, 12 and 16 foot lengths. Items marked thus * are also furnished in 10 foot lengths.

† 3-1-75 and 3-1-100 are manufactured to order only.



SLAB THICKNESS		3"	4	5	6	7	8	9	10	11	12	13	14	15	16"
WEIGHT OF SLAB	STONE	37#	50	62	75	87	100	112	125	137	150	162	175	187	200#
	CINDER	29#	38	48	58	67	77	86	96	105	115	125	134	144	153#

An illustration in actual size of our celluloid "Steelcrete" computer is here shown. It eliminates tables and calculations. It is adaptable to all building codes and specifications. It is based on the formulas of the Joint Committee. A charge of twenty-five cents post paid is made for same. A descriptive pamphlet will be sent upon request.

THE CORDAY & GROSS COMPANY
CLEVELAND